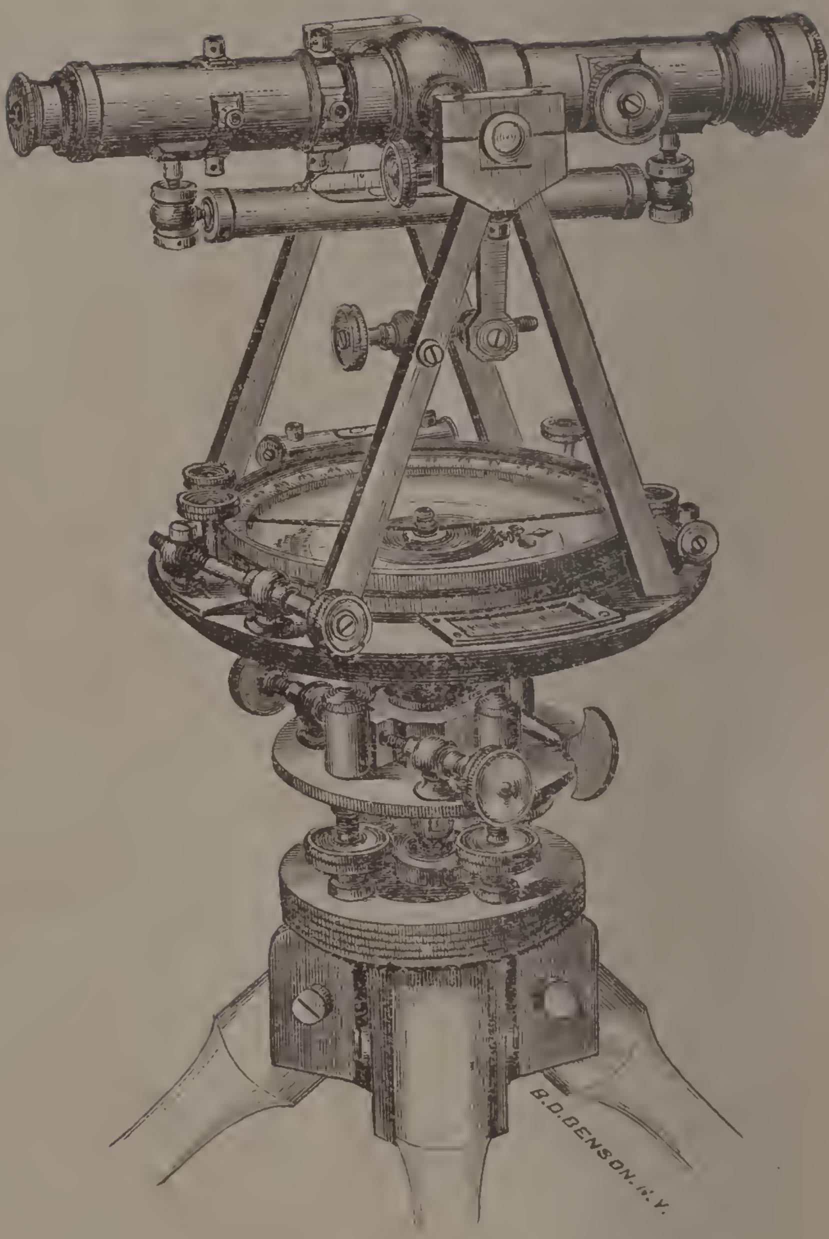


SURVEYOR'S TRANSIT.

CALDWELL'S

PRACTICAL

LAND SURVEYING,

OR

The Art of Surveying Made Easy.

ADAPTED TO THE USE OF SCHOOLS, PRIVATE STUDENTS, AND PRACTICAL SURVEYORS.

BY

M. P. CALDWELL,

AUTHOR OF CALDWELL'S ARITHMETIC, AND COUNTY SURVEYOR OF HALL COUNTY, GEORGIA.

MACON, GEORGIA:
J. W. BURKE & COMPANY.
1880.

TO

HON. J. B. ESTES.

THE

FRIEND OF MY BOYHOOD, AN UNDEVIATING FRIEND THROUGH LIFE,

AND A

GREAT LOVER OF SCIENCE,

THIS

VOLUME IS RESPECTFULLY DEDICATED.

PREFACE.

LAND is the foundation of the whole wealth of the world. Land surveying is, therefore, a most important and useful branch of study, and as an art is indispensable in carrying on many of the ordinary transactions of life. It is exceedingly desirable to be an accurate and accomplished Surveyor. In this *fast age*, when everything is done in a hurry, it becomes necessary to adopt the plan and methods which will give the student the greatest amount of useful knowledge in the shortest time and for the smallest outlay of money, that he may be thus practically prepared for the duties of life. Thousands of young men have not the time nor means to devote to a long course of preparation for surveying, and are desirous of gaining such a practical knowledge as will enable them to survey, map and estimate land in the shortest way possible. This volume has been prepared for that very large class of students as well as for the common schools and Practical Surveyors of the country. The want of such a work on Surveying is very generally felt by educators and private students, and it is hoped this want will now be met and supplied. Here the student will find the experience of twenty-five years in so small a compass as that a few weeks of pleasant study will prepare him to run land, plat and estimate it, and make his maps with ease and precision.

The Author is greatly indebted to Professor WILLIAMS RUTHERFORD, A. M., Professor of Mathematics, University of Georgia, who has had long experience as a Practical Surveyor, for many, very many valuable hints, and much assistance in the preparation of this work, as well as for several important chapters from his pen in the body of the book.

The Appendix is a rich one. For the first time ever printed the student has the *reason why* the magnetic needle stands North and

South, from the pen of that wonderful scientist, Dr. ALEXANDER MEANS, of Emory College, Oxford, Ga., in a learned chapter on the "Polarity of the Needle."

County Surveyors will be greatly interested and instructed by the chapter on their duties and synopsis of the law binding on them, from J. B. ESTES, Attorney and Counselor at Law, Gainesville, Georgia.

The carefully prepared chapter on Texas Land System and Surveying, is from Col. WARREN DOUGLAS, of Cleburne, Texas, an old official and experienced Surveyor of that State. This chapter will be peculiarly interesting to all students, and at once adapts my book to Texas schools and students as well as to those of other States.

Impartial criticism is invited by the Author, that future editions may be made more and more perfect and desirable.

M. P. C.

Gainesville, Ga., November, 1880.

NOTICE TO THE PUBLIC.

This work on Surveying is turned over to J. W. BURKE & Co. Macon, Ga., who will publish it in fine style and supply the trade. They are also the publishers of Caldwell's Practical Arithmetic. which is commanding an extensive sale and shonld be in the hands of every one who studies this work, as it will be found to be a valuable assistant in mastering the beautiful study of Surveying.

THE AUTHOR.

Land Surveying.

CHAPTER I.—Definitions.

SURVEYING is the art of running lines with a compass, taking measurements with a chain and platting and calculating the area.

A *line* is extension without breadth or thickness.

A *right* or *straight* line is the shortest line that can be drawn between two points.

A *curved* line is one that bends in all its parts.

Parallel lines are such as are equally distant from each other running the same direction.

A *crooked* line is one composed of several straight lines, joined to one another, extending in different directions.

When the word *line* is used it means a straight one unless defined otherwise.

The *bearing* of the line is the angle the line makes with the direction of the needle.

A *point* is position without dimensions.

The extremities of a line are points.

The *deflection* of a line is the turning from the true or straight course.

Surface is that which has extension in length and breadth without thickness.

A *plane* surface is a level or even surface.

Area is the amount of surface expressed in squares of any given denomination—as square inches, square feet, yards, rods, etc.

An *angle* is the inclination or opening of two lines which meet at a point.

A *right angle* is one formed by a base line and a perpendicular one to it.

Fig. 1.

An *acute angle* is one less than a right angle.

Fig. 2.

An *obtuse angle* is greater than a right angle.

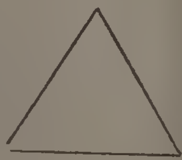
Fig. 3.

TRIANGLES.

ALL THREE-SIDED FIGURES ARE TRIANGLES.

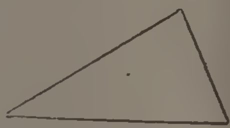
An *equilateral triangle* is one whose sides are all equal.

Fig. 4.



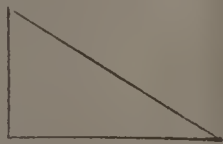
A *scalene triangle* is one whose three sides are unequal.

Fig. 5.



A *right angle triangle* is one which has a right or square angle.

Fig. 6.



NOTE.—It is composed of a *base perpendicular* and hypothenuse. The sum of the three angles of every triangle is 180 degrees; the right angle being 90 and the other two 90.

An *isosceles triangle* has two of its sides equal.

Fig. 7.

The *perpendicular* is the shortest distance from any angle of a triangle to the opposite side with which it makes right angles.

Fig. 8.

QUADRILATERALS.

ALL FOUR-SIDED FIGURES ARE QUADRILATERALS.

A parallelogram is any quadrilateral whose opposite sides are parallel and equal.

A *square* is a figure whose four sides are of equal length, and whose angles are right angles.

Fig. 9.

A *rectangle* is any right angle parallelogram.

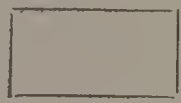


Fig. 10.

A *rhombus* has all its *sides equal* but its angles are not right angles.

Fig. 11.

A *rhomboid* is a figure bounded by four sides, the opposite ones being equal and parallel, but whose angles are not right angles.

Fig. 12.

Note.—The perpendicular height of a rhombus or rhomboid is a line drawn from one of the angles to its opposite side.

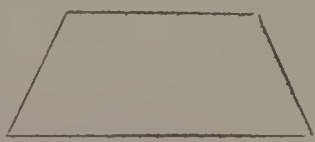


Fig. 13.

A *trapezoid* is a figure bounded by four sides, two of which are parallel, though of different lengths.

Fig. 14.

A *trapezium* is a figure bounded by four unequal sides, no two of which are parallel.

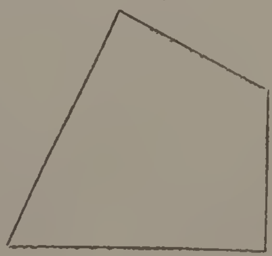


Fig. 15.

A *diagonal* is a line drawn between opposite angles.

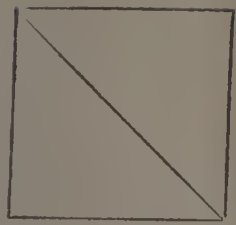


Fig. 16.

Figures with more than four sides are called *polygons*. If the sides are equal the figure is called a regular polygon; if unequal, an irregular polygon.

CIRCLES.

A *circle* is the space bounded by a curve line, every part of which is equally distant from a point within called the centre.

Fig. 17.

The *circumference* of a circle is the curve line which bounds it.

The *diameter* of a circle is a straight line passing through its centre, terminating at the circumference.

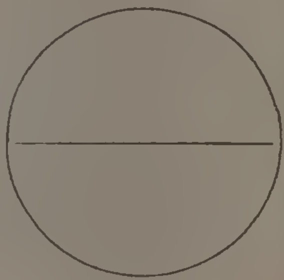


Fig. 18.

The *radius* of a circle is the distance from the centre to the circumference.

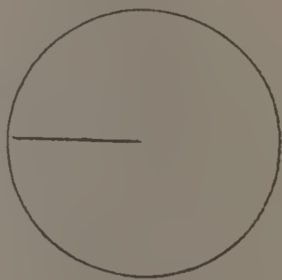


Fig. 19

An *arc* of a circle is any part of its circumference.

Fig. 20.

A *chord* is a straight line drawn from one end of an arc to the other, and is the measure of the arc.

Fig. 21.

A *tangent* is a right line which touches a curve at one extremity of an arc.

Fig. 22.

The *segment* of a circle is that portion cut off by the chord.

Fig. 23.

Platting is representing on paper the lines and angles measured on the ground.

A *map* of a survey represents the lines which bound the surface surveyed and the objects upon it, such as houses, hills, rivers, roads, etc., in their true relative positions and dimensions.

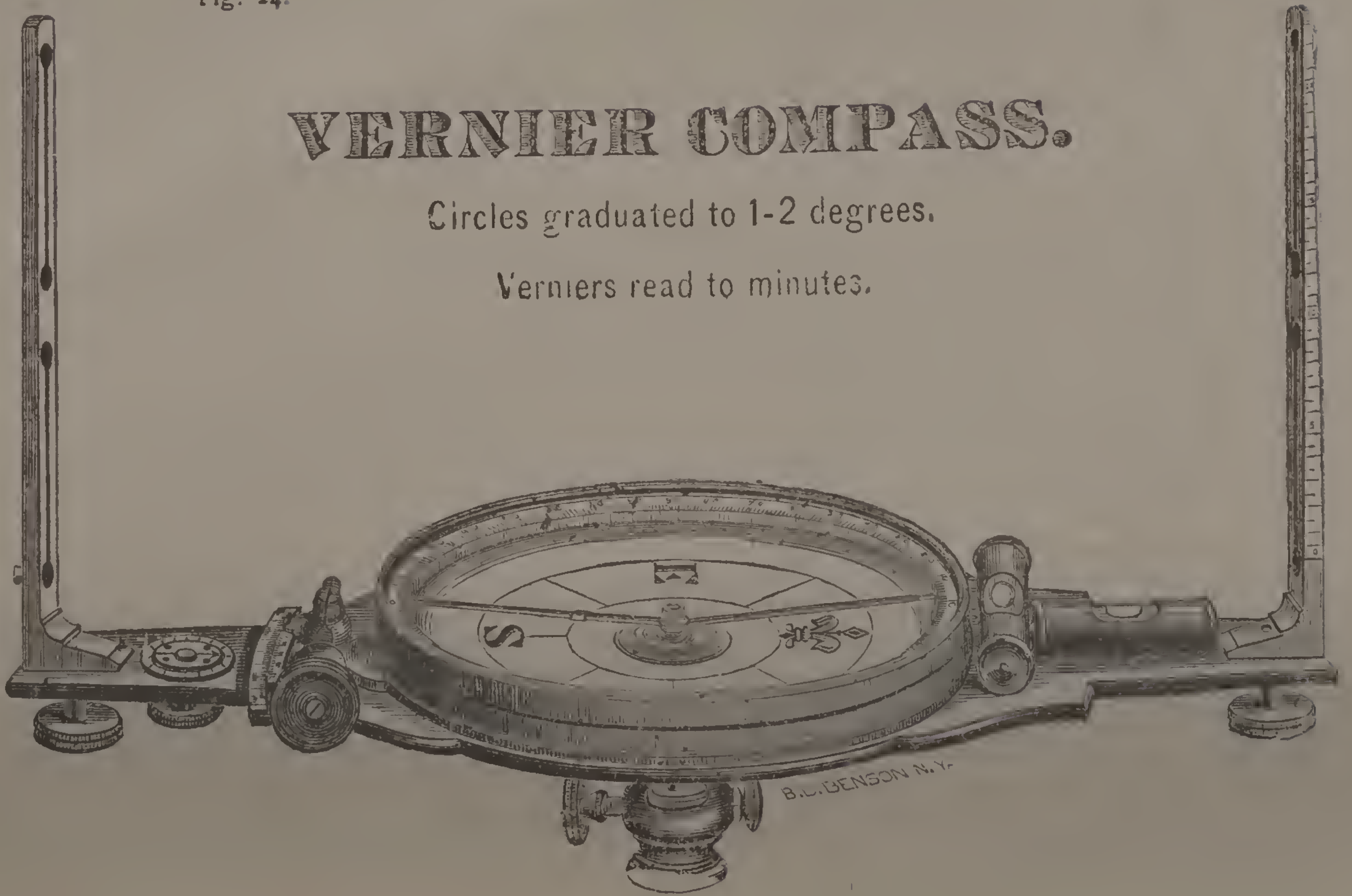
A *plat* of a survey is a skeleton, or outline map. It is a figure similar to a map having all its angles equal and its sides proportional.

Fig. 24.

VERNIER COMPASS.

Circles graduated to 1-2 degrees.

Verniers read to minutes.



CHAPTER II—Instruments.

THE COMPASS.

The main instrument used in all surveys is the Compass. It should be thoroughly studied and understood before any field work is attempted. The cut on the preceding page represents a plain Surveyor's Compass with a Vernier plate attached.

A Compass is made on a brass plate, and is composed of a compass box, the interior of which is a graduated circle divided to degrees and half degrees, and numbered from 0 at the North and South end to 90 on the right and left. At the centre is a small pin on which the magnetic needle plays. The length of the needle is a very little less than the diameter of the graduated circle, so that it can move freely around its centre, within the circle, and its positions be noted on the graduated arc.

At each end of the Compass is a perpendicular brass sight fastened to it by thumb-screws. In each sight there are holes or small apertures and slits. In some Compasses this sight is simply a thread or hair drawn vertically through the middle; in others, merely small apertures or slits in the brass. These sights are set on the Compass-plate centrally over a line passing through 0 at the North and South or N. and S. end of the graduated circle. All these arrangements are intended to enable the line of sight to be directed to any desired object with ease and precision.

A Vernier, which is a movable graduated plate for measuring smaller portions of space than those into which the line is actually divided, is attached to most Compasses. It consists of a second line or scale, movable by the side of the

first and divided into equal parts, which are a very little shorter or longer than the parts into which the first line is divided. The Vernier is permanently attached to the Campass-box, and is moved about the centre by means of a thumb-screw on the right or left. When the Vernier is not used care should be taken that the 0 should coincide precisely with the 0 of the Compass-plate. When a needle is well magnetized and the centre nicely pointed it will play lively and long. When it ceases to move, by giving the staff or compass a light rap it will sometimes move slightly and rest a quarter, half, or a whole degree from the true point. This is nearly always true when the needle settles quick. It is sure evidence that something is out of order. The needle, therefore, should not come to a rest very quickly. If it does, it indicates either that it is weakly magnetized or that the friction on the pivot is great. When it is very sensitive and lively it will be indicated by the number of vibrations it makes in a small space before coming to rest. The needle should always be raised off the pivot when the instrument is being carried about, that the point may not be dulled and cause unnecessary friction. But when the Compass is not in use the needle should be free on the centre pin that, by keeping its polarity, the magnetic power will strengthen rather than weaken.

In many Compasses each end of the needle does not rest or point at the same degree; care should therefore be taken to always read the courses from the same end of the needle, which should be the North end. Any Compass is liable to this trouble when it is not level. Compasses differ in their directions because different needles do not point alike at the same place. It was well known to the celebrated Rittenhouse, who manufactured instruments, that his Compasses did not agree, and he was never satisfied as to the cause of it. As correct a survey may be

taken with one as with another of this class, and we may naturally ask the question, which of these varying Compasses is correct? We answer, all are correct. All that can be said of them is, that one makes a greater declination than another, and that which makes the least cannot have the preference. To remedy this defect, if it is properly a defect, the Vernier scale can be used to regulate the difference and make all agree on the same meridian. The meridian should be established by the motion of the heavenly bodies and made permanent by durable monuments.

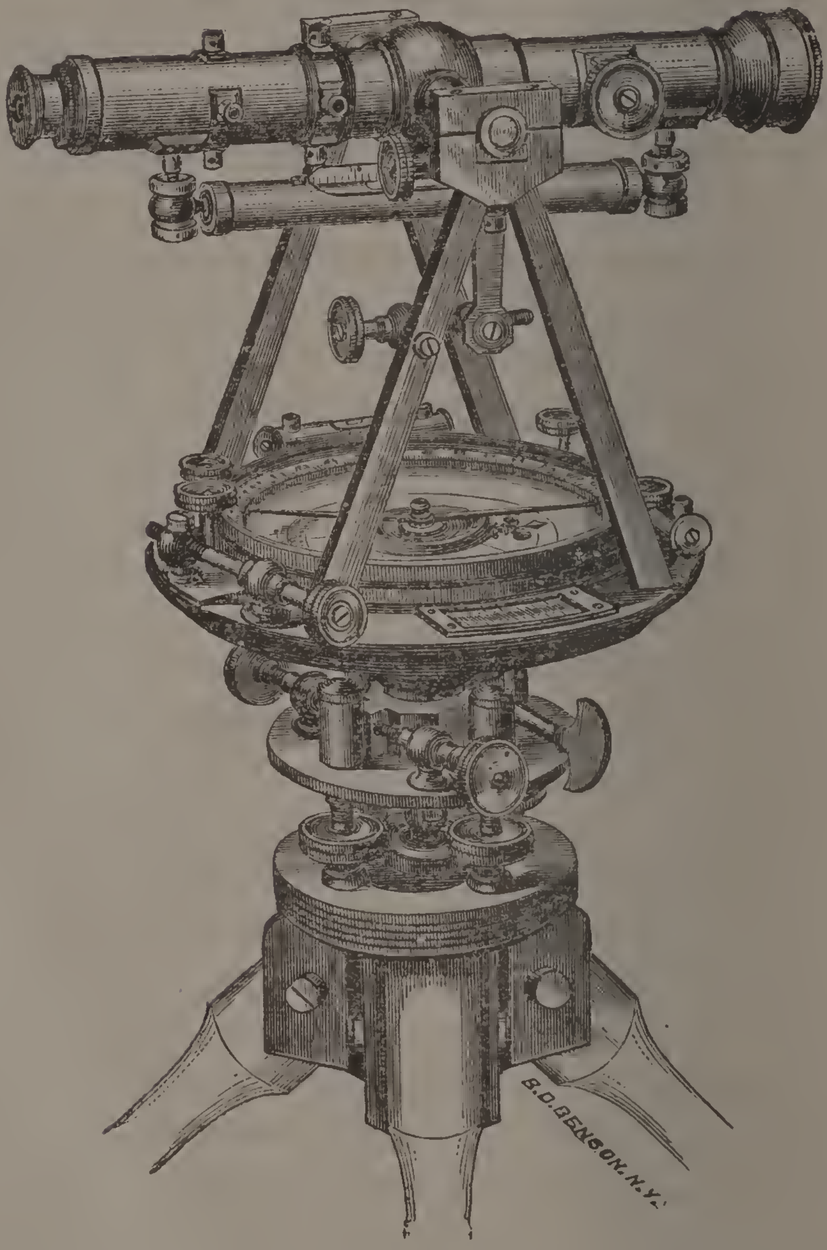
All courses are counted North or South so much East or West. That is, the angle which a course makes with its meridian is written North so much East or West, or South so much East or West, unless the needle reads 90 degrees; in that event the course is either due East or due West.

The North end of the Compass' dial is generally indicated by some ornamental drawing or the letter N; the opposite end by the letter S; the left hand by E, and the right hand by W. The latter may seem to be the reverse of what it should be, but a little thought will prove its correctness. Suppose the North end of the Compass be turned due East, the needle reads 90 under or at E, showing that the course is East, and *vice versa*. Should the North end be turned due West, the needle reads 90 at W, showing that the course is West. Thus the lettering is correct, and is an unerring guide in taking bearings.

The Compass is generally supported on a single leg, called "Jacob's Staff," which should be shod with iron or steel. A temporary one may be made of any wood at the place where it is to be used, thus saving the trouble of carrying it from place to place. It is much better, however, to have one of good durable wood mounted with the usual brass ball and socket. It admits of motion in any direction, levels the instrument easily, and can be tightened or loosened by turning the upper half of the

hollow piece or case enclosing it, which is screwed on the lower half.

THE TRANSIT.



This useful instrument is essentially a Vernier Compass, to which is attached a telescope supported by upright standards firmly fixed to the movable plate. The telescope can turn completely over so as to take back and fore sights—hence the name Transit. The chief advantage of the Transit over the Compass in common surveying is the

use of the telescope, which enables the Surveyor to prolong lines to a greater distance and with more precision than with the eye. I will not give an extended description of the Transit for the reason that it is seldom used in land surveying. It is a heavy instrument supported on a tripod which renders it impracticable for common use. Its principal use is in railroad surveying.

THE CHAIN.

The measure most commonly used in land surveying is a chain 66 feet, 4 rods, long, and is composed of 100 links made of wire. Every tenth link is marked by a brass tag having one, two, three and four points numbering the tens from the hind end of the chain. This chain was invented by Mr. Edward Gunter, and is usually called "Gunter's chain." The length, 66 feet, or 4 rods, was chosen because each square chain contains 16 square rods, and 10 square chains make one acre. Since each link is the hundreth part of the chain, and links therefore deci-

mal parts, they may be so written, 4 chains and 65 links, simply being 4.65 chains, and all calculations in chains and links can be easily made by the rules of common decimals in Arithmetic. Each link is 7.92 100 inches long. To prevent a very common error of calling ten, forty, or twenty, thirty, care should be taken by the Surveyor to see that the proper end of the chain is before. That is indicated by the greatest number of points on the brass tags. Most all field work is done with a half, or 2 rod, chain, which is more convenient than a whole chain. It is composed of 50 links, numbered as above, by the brass tags. In taking measurements with the half chain the number must be halved to get the correct number of chains, but links should not be.

A chain 50 feet or 100 feet long, each link 12 inches long, is frequently used in taking measurements and is very convenient to count. It likewise has the brass tags, the same as Gunter's chain. It is very easy to reduce the feet to chains and links by simply dividing by 66 and continuing the division to two decimal places for links, which, as stated above, are merely hundredths of chain.

To reduce chains and links to feet multiply by 66 and cut off two figures from the right for decimals ; if no links, the product of chains by 66 is the number of feet. The Author uses a 50 feet chain in surveys, and makes all calculations of area by feet, stating length of lines on plats and maps in feet. He prefers this method of measurement as it is just as accurate as by chains and links, and much more easily used in platting and more readily understood or comprehended by the people. When measurements are taken in feet the platting should be in feet or by the foot.

CHAPTER III—How to Chain.

Chaining is the foundation of all kinds of Surveying. Two hands are required to chain, and they should be careful and attentive to their duties. The chain should be measured to see that it is correct in length. All lines in land surveying must be measured horizontally as if level like a plane. A hill thus measured will give the same contents as the level base upon which it is supposed to stand. Thus in chaining slopes, the chain should be carried level; if going up the slope, the fore chainman puts his end of the chain down and the hind chainman raises his end of the chain to a level, taking care that the end is vertically over the pin or point. And in going down the slope, the hind man holds down at the pin and the fore man holds up to a level and drops the pin on a perpendicular. This is the only method by which the correct measure of uneven surfaces is obtained. Eleven pins are required in chaining—the fore chainman starts with ten, leaving one to the hind man. The chain should be tightly stretched every measure, the hind man placing the end of the chain against or directly over the pin and calling out "stick;" the fore man sticks a pin and calls out "stuck," when the hind man takes up the pin, and never until that announcement is made, and goes forward to the next pin, and so on. When the fore man gets all the pins stuck he should announce "out," distinctly, when the hind man drops the chain and carries up the pins, counting to see that there are ten.

Both put a small rock or something of the sort in their pockets to number the "outs" or tens. The fore man now starts off anew with ten pins, as at first, the hind man

measuring from the last pin stuck down. When the objective point, or end of the line, is reached, get as close to it as possible with full chains and carefully count the links from the last pin to it. The hind man announces the number of pins in his hand, without the last one stuck. Then to make up the length of the line count the outs, or tens, multiply the number by ten and add the number of pins in the hind man's hand; this will give the number of chains, to which add the links. Of course if the chain comes out even, then the hindman is entitled to the last pin stuck down.

Too much care cannot be taken in chaining, especially on broken or uneven lands. The very best that can be done, the lines of such lands are generally made too long. A judicious, experienced Surveyor can form a pretty correct idea what allowance to make in such cases. It may be asked why the chain should be leveled every measure. We answer, in common surveying the earth is considered a plane and therefore level acres are what are required. And, again, if the length of slopes and undulations be taken, the measure is entirely too long and the contents would be too much. By a little thought on this subject we may readily see that no more houses can stand on a hill than would occupy the level base, if the hill were removed. Neither can more trees, corn or other plants which grow vertically.

I have dealt thus at length upon chaining because I desire to impress upon all Surveyors, and more especially upon the young Surveyor, the vast importance of being careful and accurate in this branch of the work. Careless chaining has caused and does cause most of the troubles in land matters, and embarrasses even the best of Surveyors.

CHAPTER IV—Field Work.

COMPASS SURVEYING.

See that the compass is all right before any work is attempted, then set it at the starting point or corner. Then, from the very best evidence at hand, get the bearing of the line. It is generally best to walk out on the line to look for marks, if an old line, as a better idea of the direction or bearing of the line may thus be obtained, and then by setting the compass on the marks a start may be made. The Author, in traversing old lines, generally takes the compass out on the line to marks, and sets it, between marked trees, if possible, taking a back sight back on the corner or a range pole at the corner. Then, by taking a sight forward, walk out on the line farther and examine for other evidence or marks. If the compass leads off of the marks, the bearing can then be changed and a more correct start made. But if no evidence of the old line be discovered the bearing thus taken should be run through as a random line, the chainman following as directed before. Should the objective point or corner be missed the true bearing of the line can readily be determined by rule on page 38 for *random* lines. The instrument can then be placed on that corner, the true bearing applied and the line be correctly run back to the first or starting corner. In that case, it would be useless to chain back as the true length was obtained by the first measurement.

As before remarked in this work, the compass is subject to local attractions, such as iron ore beds, or ferruginous substances, hence, to guard against error from this source, it is always safe and proper to take a reverse or back-sight

from every station. If this and the forward bearing are the same, that is, if the needle registers or reads the same degree, the work is probably correct, but if they differ much both should be taken again. Taking the reverse sight on a line is generally a great assistance in producing a straight line, as well as a safeguard against local attraction.

In farm surveying it frequently happens that the boundaries are occupied by fences or borders of shrubbery, so that it is difficult to chain or to traverse with the instrument. In such cases it becomes necessary to make an offset of sufficient distance to clear the obstacles. The offset stops short or goes beyond the true line a certain distance, and the bearing must be the same as the line and of sufficient length to pass or clear the obstacle.

In making these offsets great care should be taken to have the ends at right angles with the line. This can be done by the eye, in short distances, but should always be done by the compass in long lines. The offset can generally be measured by the flag-staff or Jacob staff. Offsets are not only frequently necessary but very convenient in surveys; but the Surveyor should use them with great care and judgment.

The foregoing instructions relative to tracing old lines or producing new ones presume them to be straight. It not unfrequently happens that old lines are crooked, and the Surveyor will find that no set bearing or variation will traverse them, but he will have to content himself with following the old marks, provided always, it is not determined to produce the line straight from corner to corner. In this State (Georgia) the law on old lines is:

"Natural landmarks, being less liable to change, and not capable of counterfeit, shall be the most conclusive evidence; ancient or genuine landmarks, such as corner station or marked trees, shall control the course and distances called for by the survey. If the

corners are established, and the lines not marked, a straight line, as required by the plat, shall be run, but an *established marked line, though crooked*, shall not be overruled; courses and distances shall be resorted to in the absence of higher evidence."—*Code of Georgia, Section* 2387.

(See, also, chapter on Duties of County Surveyors, page 87, of this work.)

After an experience of thirty years in Practical Surveying, the Author finds it impossible to bring old lines down to a regular standard of variation or bearing, or adopt any rule which may be relied on with certainty for re-estabishing lost lines or old lines, on account of the irregularities of the magnetic needle and the difference between compasses and the careless and incorrect manner in which most of the former surveys were made. It is a noted fact known to all Surveyors of experience that "the original surveys of lands in the older States of the American Union were exceedingly deficient in precision. This arose from two principal causes—the small value of land at the period of these surveys, and the want of skill in the Surveyors. The effect at the present day is frequent dissatisfaction and litigation. Lots sometimes contain more acres than they were sold for and many times less. Lines are frequently longer or shorter than laid down on papers, and those which are straight in deeds and on the map are crooked on the ground. The recorded surveys of two adjoining farms often make one overlap the other, or leave a gore between them. The most difficult and delicate duty of the Land Surveyor is to run out and establish these old boundary lines. In such cases, his first business is to find corner stones, or monuments, marked trees, stumps or any landmarks. These are his starting point and guide. His business is to mark out on the ground the lines given in the papers."

In districts or sections where the land is laid off in regular lots, it is easy to recheck it with the compass, starting from some well known base line, but in head-right districts it is more difficult to prove the accuracy of the work. It is best and generally necessary to traverse the lines twice or more, noting the variations on each, that true lines may be established, even if the employer does not see the necessity of being so particular. In surveying water lines, branches, creeks or rivers, run with an offset, generally keeping on the same side of the stream and as nearly as practicable about the same distance from it, noting in the field-notes the distance from each station to it so as to draw the shape of the stream on the map.

CHAPTER V.

VARIATION OF THE MAGNETIC NEEDLE.

BY

PROFESSOR WILLIAMS RUTHERFORD, A. M.,

UNIVERSITY OF GEORGIA.

All that will be attempted in this article will be to deal with facts of science without any attempt to explain them, as this is intended simply as a Treatise on Practical Surveying.

It is known to scientific men that the magnetic needle is never absolutely still, but that it moves from East to West and back from West to East, making different angles with the true meridian, of different places on the earth's surface. If the points of attraction were exactly at the poles of the earth there would be no variation, for the needle would coincide with every meridian on the earth's surface, in all latitudes. This has long been known not to be the case. The points of attraction, whatever be the cause, are not at the poles, but are removed several degrees from each pole. Hence a magnetic needle located on a meridian which does not pass through these points will make an angle with this meridian differing in amount according as the meridian is near or rémote from the one that does pass through these points, and differing again according to the latitude of the place—in higher latitudes the angle being greater than in lower. If these points were permanently on the same meridian, while the needle would vary more at one place than at another, there would be no change in the variation for each place. Instead,

however, of being permanently on the same meridian they revolve around the North and South poles in about six hundred and sixty-seven years. So that the magnetic needle, being always directed to these points, must follow them in their motion around the poles.

Suppose a needle be placed upon the meridian which passes through these points of attraction, it will coincide with that meridian, and there will be no variation. If, say the point of attraction nearest the North pole were moving in its orbit around that pole at the rate of one revolution in six hundred and sixty-seven years, in one-fourth of that time, that is, in one hundred and sixty-six years, the needle will be at what is called its greatest elongation, or, in other words, will make the greatest western variation. It will then follow the attracting point around the orbit, and begin to move back toward the East. At the end of about one hundred and sixty-six years more the point of attraction will have arrived at the same meridian upon which the needle is placed, and there will the needle again coincide with that meridian and there will be no variation.

Still moving eastward, at the end of about one hundred and sixty-six years more it will have attained its greatest eastern elongation, and then the needle will mark the greatest angle of variation eastward. After this, following the point of attraction, it will move westward, and in about one hundred and sixty-six years more will again arrive at coincidence with the meridian upon which it is placed, being in precisely the same condition as when it started, and will run the same round in another period of six hundred and sixty-seven years.

With these facts, which have been developed by science, it will be seen that the magnetic needle has a constant though exceedingly slow motion. The motion is so slow that for a year or two the difference in the bearing would not be observed when marked by an ordinary compass.

But for a number of years, the difference becomes of vast importance to owners of land separated by a straight line, if all the landmarks be removed. As already stated, the variation is not the same for all localities. It becomes important for every Surveyor to first determine the *annual variation* of the needle for his locality or county. The best practical method to determine this is to select some well marked line in the neighborhood, the *date of whose survey* is accurately known, as well as the *bearing* at the time of the survey. Place the compass accurately on this line, and, after the needle has finally settled, take the bearing. It will be seen that it is *not the same* as the old bearing. Take the difference. This will be the *total* variation for the *period* of time which has passed between the time of the original survey and the present test. Reduce this difference to seconds and divide by the number of years which have elapsed since the first survey. This will be the *annual variation* for that locality, in seconds. If more than sixty, it will be minutes and seconds. The surveyor should not be content with one such test, for it is found in practice very difficult to get the exact bearing from marked trees. He should take his compass to another portion of the line and make the same careful trial, and if there are more than one such well marked line in the county, the date of whose survey is accurately known, those should be tested in the same careful way.

After taking several such observations, carefully noting the bearing each time, add all the results together and divide by the number of observations, and a mean of all will be thus obtained which may be permanently recorded as the true annual variation for that neighborhood or county. To illustrate: Suppose the surveyor places his compass upon a line which he knows was surveyed October, 1840—just forty years ago—and the then bearing reads N. 15° 30′ W., and finds that the present bearing at the first

point tested reads N. 14° 15′ W. He goes to a second point, and finds that the bearing reads N. 14° 45′ W. He adds these two bearings together, making 29°. Dividing by two, he finds the average bearing to be 14° 30′. He decides that the present true bearing of the line is N. 14° 30′ W., making a difference between the old and new bearing of exactly one degree, or sixty minutes. The time between the two surveys is forty years. Now divide the total variation by forty, and the result is one minute and a half or 1′ 30″. This is noted as the annual variation for the locality. Remembering this as his annual variation he will apply it to every line he runs by an old deed or plat which gives the *date* of survey. If the time between the date on the plat or deed is ten years, then multiplying 1′ 30″ by ten, the result is fifteen minutes, which is the variation to be applied in tracing the old line. If twenty years have elapsed since the old survey, then multiply 1′ 30″ by twenty, which gives 30′ as the variation to be applied. The next thing to be done is to properly apply the variation when found.

The variation in all States west of Pennsylvania is *East*, and the North end of the needle is moving westward. Hence the total variation is becoming less every year. If the bearing is N. 15° W., the North end of the needle is on the *right* of the line and moving westward the angle is becoming *less*. In this case the variation must be *subtracted*. Suppose that the annual variation is 1′ 30″, and twenty years have elapsed since the old survey. This gives 30′, which must be subtracted from the old bearing, say N. 15° W., making the present bearing N. 14° 30′ W. Running with this bearing the old line will be traced; but if the old bearing is N. 15° E. the needle is on the left of the line, and the north end moving westward will *increase* the bearing by the amount of variation. Hence at the expiration of twenty years the 30′ variation must be *added*,

making present bearing N. 15° 30′ E. This, it will be remembered, is simply an illustration.

As said above, each surveyor should determine the annual variation for his county and apply the rule to that variation. There is a simple rule by which it may always be determined whether to add or subtract the variation. The rule is this: *If the end of the needle is on the right of the line, subtract. If on the left of the line, add. This rule will hold good, whether reading the angle from the North or South end of the needle.*

To show the importance of always attending to the variation of the needle a few facts may be stated.

Suppose that the annual variation for a county be 1′ 30″, and a surveyor be required to trace an old line two miles long between two neighbors, where every mark has been obliterated and only one corner is known to be a point on the line; and suppose that the original line had been run forty years ago, the variation would amount to one degree. Now suppose the surveyor, as usual, runs by the old bearings which he finds in the deed or plat, he will leave the true line one degree, and in running one mile he will cut off about five and a half acres from one tract and give it to the other. If the dividing line is two miles, or one hundred and sixty chains long, he will cut off 22.4 acres from one and give it to the other.

Again, suppose the old survey had been made eighty years ago, then the variation will amount to two degrees, and if the surveyor runs by the old bearings, in one mile he will cut off 11.11 acres from one and give them to the other; and if the line be two miles long he will cut off 45 acres, nearly, from one and give to the other. It will be seen at once why it is that so many disputes arise about land lines.

That this trouble may be avoided in future let every surveyor determine the annual variation for himself and

always apply it when practicable, and when he makes a plat be careful to put upon it, after the scale, the annual variation and *date* of the survey. Then any subsequent Surveyor can, with this plat in hand, trace the old line accurately though every mark except the corner be obliterated.

CHAPTER VI.

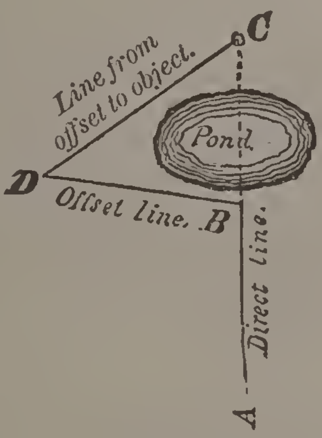
PASSING OBSTACLES.

BY

PROF. WILLIAMS RUTHERFORD, A. M.

It often happens that in running a line, obstructions are encountered, which cannot be conveniently passed. If it be a pond of water, and the chain-bearers are unwilling to wade it, or if it be too deep for wading, it becomes necessary to adopt some expedient by which it can be passed without going directly through it. If a tree, or any well-marked object, can be seen in the direct line across the pond, *note it.* Then take the bearing to some

FIG. 25.



Object across the pond, which can be seen from B.

convenient point from which a direct line to the object noted can be run without encountering the pond. Measure

this new bearing, and note both bearing and distance accurately. From this new position take bearing to the first object noted across the pond, and measure this line to noted object. When the field work is to be platted, these two last lines must be laid down, and the end of the last will be in the direct line *across* the pond. Connect this point with the point where the offset line was taken, and apply it to your scale, and thus determine the true distance across the pond, which must be added to the other measurements of the direct line.

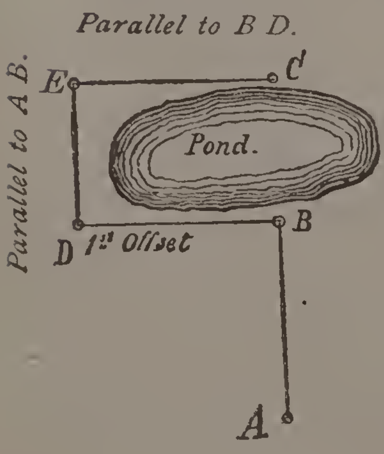
ILLUSTRATION.

The line A B (Fig. 25) is measured. The bearing from B to D is taken, and the line measured. The bearing and distance from D to C are taken and measured. When platted, one foot of the dividers is placed at C and the other at B, and applied to the scale, and the distance counted as are all other distances in the same plat.

FIRST METHOD.

If no object can be seen, then a different method must be adopted. When the point B is reached (Fig. 26), turn at right angles to A B until the point D is reached, from which the line D E parallel to A B will pass the pond. Then from E run E C parallel to first offset and of the same length. The point C is in the direct line, and the length of E D must be added to A B, making the direct line from A to C known.

FIG. 26.



To find distance to inaccessible object with chain or rod pole alone.

Let it be required to find the distance across a river to

any object on the opposite bank, when the person has no instrument with which to measure angles.

SECOND METHOD.

Let A be the object on the opposite side of a river, and it be required to find the distance from B to A. Place a man or stake at B, and measure accurately B F in a direct line with A B. Then measure F E at right angles from the line A F to a convenient distance F E. Then standing at E, look towards A, and place a man or stake at D in line with A, and also in a line B C parallel and equal to F E. Then measure D C. There will thus be formed two similar triangles D C E and A B D. Their homologous sides can be compared thus: D C : C E : : B D : A B. It will be seen that as we have the length of D C, C E, and B D, we can find by the ordinary rule of three the value of A B, the distance desired.

FIG. 27.

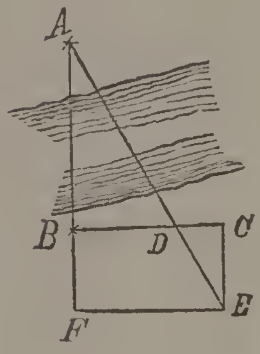
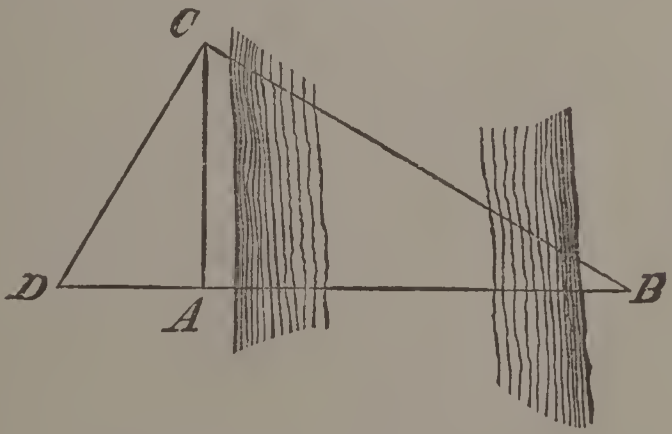


FIG. 28.



WITH A COMPASS AND CHAIN.

Let A B (Fig. 28) be part of a line of survey in which A and B are on opposite sides of a river. From A at right

angles to A B lay off any convenient distance, as A C, so that B may be seen from C; remove the instrument to C, and lay off C D at right angles to C B, fixing the point D in A B produced, and measure D A. Then square the length A C and divide by D A; the quotient will be the distance A B, the width of the river.

CHAPTER VII.

RANDOM LINES.

BY

PROF. WILLIAMS RUTHERFORD, A. M.

To run a straight line between two corners or points where all intermediate marks have been obliterated, and the corners cannot be seen the one from the other.

It frequently happens that a person wishes to sell a piece of land to a line running from one point to another which cannot be seen, and again it may be desired to run an old line between two such corners, when every marked tree or other monument has been destroyed and the original bearing lost. Set your compass at one of the corners, and direct the sights as nearly as you or some one present may guess to be the direction. Note your bearing and measure *accurately* until opposite the other corner or point desired, if not exactly in the line run. Then measure the offset to the corner. This offset, random line just run, and the true line, will form a triangle, and the angle at the starting-point will be the angle by which you missed the true bearing.

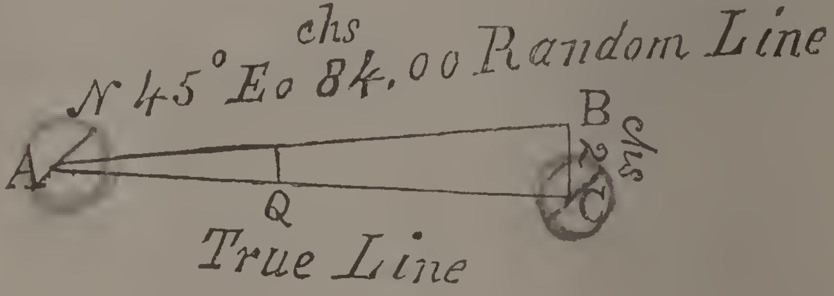
There are two practical methods of finding this angle without the use of a table of tangents, which the surveyor seldom carries with him.

FIRST METHOD.

Make this statement: As the length of the line measured is to the offset by which you missed the second corner, so is 57.3 to the number of degrees and tenths of a degree in the required angle. Having reduced the tenths of degrees

to minutes, set your compass at the corner missed, and turn your sights until the same angle is indicated by the needle with which you ran your random line. Now looking in the line of *back-sight*, turn your compass towards the corner from which you started, until the needle passes over the degrees and minutes obtained by the above statement. Note the bearing now indicated by the needle and run back to the corner, marking trees or setting stakes. If the work has all been accurately done, this will be the true line, and take you back to the beginning corner. An illustration will be given to be sure that the student will understand the method.

FIG. (*a*.)



Suppose A is the point at which you start, and C is the second point you wish to reach. Place compass at A, and direct along the line A B; say that the bearing is N. 45° E., and the distance from A to B, opposite C, measures 84 chains, and the offset from B to C measures 2 chains.

FIG. 29.

Then you have

84 : 2 :: 57.3 : o Q, the arc which measures the angle B A C.

$$\begin{array}{r} 2 \\ \hline 84\ )114.6(\ 1^\circ.364 \\ 60 \\ \hline 21.840 \end{array}$$

The angle is found to be 1°21′.8.

After calculating thus, set your compass at C, and turn the sights until the needle stands at S. 45° W. when looking in the direction of A. When the needle is well settled, move sights towards A until the needle passes over 1° 22′. Then read bearing, and this will be the true bearing between the corners.

From the above illustration we have the following simple rule:

Multiply the offset by 57.3, and divide by the length of the line. Then add or subtract as required.

SECOND METHOD.

Run line as in the first method. Double the distance (A B) and multiply by 3.14159. The product will be the length of the circumference of a circle, whose radius is A B. The offset (B C) will be a part of the circumference which measures the angle B A C. If the whole circumference of the circle be divided by 360, the length of one degree will be found. The true length of the offset (B C) compared with the measure of one degree will give the degrees of the angle B A C. Illustration by the same example: 84 chains being the measured distance from A to B, the double distance will be 168. This multiplied by 3.14159 gives 527.78712. This divided by 360 gives as a quotient 1.466. Now divide the offset 2 chains by this result, that is

$$\frac{2}{1.466} = 1^\circ.364$$
$$\begin{array}{r} 60 \\ \hline 21'.840 \end{array}$$

giving the angle B A C 1° 21′.8, precisely the angle obtained by the first method. Having found this angle, proceed just as directed in the first method.

CHAPTER VIII.

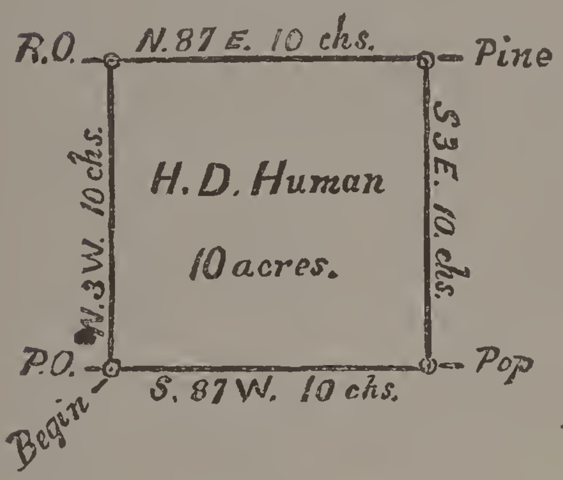
KEEPING FIELD-NOTES.

This is an important branch of the work, and the surveyor must not only be correct, but also exceedingly careful in recording his field-notes, so as to be able to make an accurate map. An error here may make it necessary to do the entire work or a great portion of it over. A small blank book of convenient size for the pocket is provided. Enter the date of the survey, what survey it is, for whom done, and the names of the chainmen. Then describe the beginning corner carefully and fully, set the instrument on it as before directed; get the bearing of the line, which is entered in the book, together with all objects on the line it is desired to note. The line is produced through on the bearing noted, and the length measured by the chainmen. The length is then entered opposite the bearing, and the second corner or station mentioned. Set the compass on this second corner, take and enter the bearing and length as before, noting all objects necessary for an accurate map. Continue with every line until the starting-point is reached and noted.

It matters little which way the land is run, whether to the right or to the left. But a map looks better with the courses and distances taken with the course of the sun—that is, with the land on the right. All the rules deduced for the one case are equally applicable to the other. To

illustrate the above method of taking and recording the field-notes of a survey, it may be well to give an example or two.

FIG. 30.



August 18, 1880.

THE "PICKET SURVEY."

FOR H. D. HUMAN.

JOHN CHARLES, } *Chainmen.*
WILLIAM ROE, }

Begin Post Oak, southwest corner of the survey.

Thence	N. 3	W.	10 chs.	Red Oak.
"	N. 87	E.	10 chs.	Pine.
"	S. 3	E.	10 chs.	Poplar.
"	S. 87	W.	10 chs.	Beginning.

If the measurements are in feet, the field-notes would read :

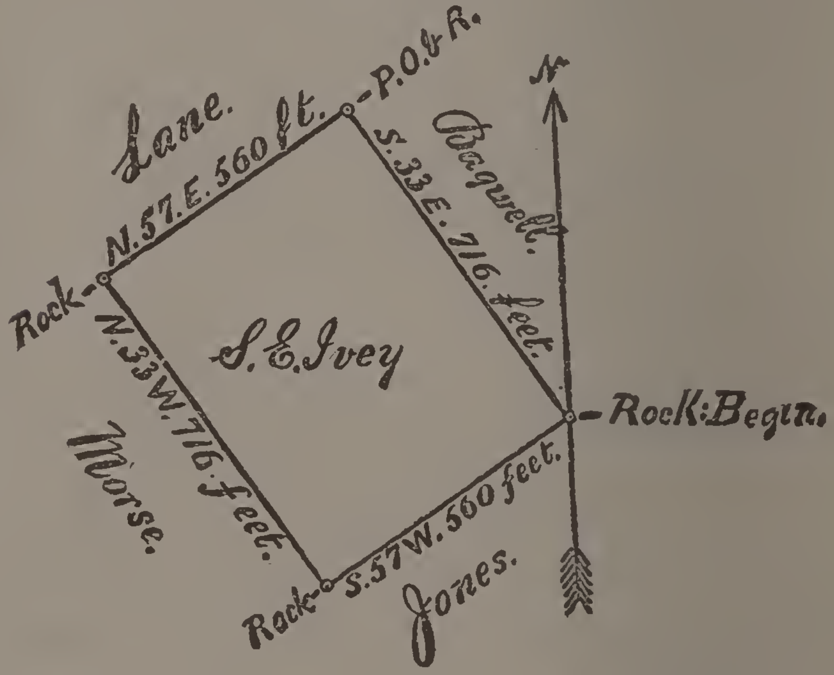
Begin at Post Oak, southwest corner of the survey.

Thence	N. 3	W.	660 feet.	Red Oak.
"	N. 87	E.	660 feet.	Pine.
"	S. 3	E.	660 feet.	Poplar.
"	S. 87	W.	660 feet.	Beginning.

The above plan of keeping field-notes is used by the Author. It is plain, easy, and simple. Of course, where the survey is more complicated, and it is desired to note

various objects, such as houses, fields, branches, roads, etc., the notes must be fuller and more explicit. Another good plan is to make a rough pencil-sketch of the survey by the eye, and write down on the lines their bearings, lengths, and corners. Upon this sketch it is easy to represent branches, houses, fields, and all objects necessary for a full and clear map, and also the names of adjoining land-owners. I will give a few more examples, which will suffice to show and teach the student how to keep his field-notes, and from which he can make his maps and estimates.

FIG. 31.



November 3, 1879.

THE "S. E. IVEY SURVEY."

JOHN MORSE, } *Chainmen.*
JASPER JONES, }

Begin at Rock, southeast corner of lot and corner of lands of Bagwell and Jones.

Thence	S. 57 W. 560 feet.	Rock.—Morse's corner.
"	N. 33 W. 716 feet.	Rock.—Lane's corner.
"	N. 57 E. 560 feet.	P. O. & R.—Bagwell's corner.
"	S. 33 E. 716 feet.	Rock.—Beginning.

October 4, 1879.

THE "BOYD" LOT.

FOR JOHN C. JARRETT.

JOHN C. JARRETT,
B. F. SMALL, } *Chainmen.*

Begin at Rock on Jefferson road, near the Jarrett dwelling.

Thence N. 84½ W. 1475 feet along said road to Red Oak.

Thence S. 1¼ W. 600 feet to White Oak in fork of branches.

Thence S. 34 E. 562 feet to Gum, the corner of Harmony church lot.

Thence N. 43¾ E. 350 feet to Rock, the corner of Harmony church lot.

Thence S. 46¼ E. 218 feet to Rock, the corner of Harmony church lot.

Thence N. 43¾ E. 1079 feet to Beginning corner.

David H. Jarrett marked the lines.

W. P. MANGUM,
T. N. BUFFINGTON,
WILLIAM R. CATO, } *Processioners.*

To record the above survey on a reverse run:

Begin at Rock corner on Jefferson road, near the Jarrett dwelling.

Thence S. 43¾ W. 1079 feet to Rock, corner of Harmony church lot.

Thence N. 46¼ W. 218 feet to Rock, corner of Harmony church lot.

Thence S. 43¾ W. 350 feet to Gum, corner of Harmony church. lot.

Thence N. 34 W. 562 feet to White Oak, in fork of branches.

Thence N. 1¼ E. 600 feet to Red Oak, on Jefferson road.

Thence S. 84½ E. 1475 feet along said road to Beginning.

September 4, 1879.

FOR J. M. THOMPSON.

W. A. DUNAGAN,
GEORGE R. WATSON, } *Chainmen.*

Begin at Willow on west bank of the Oconee River, Hancock's corner.

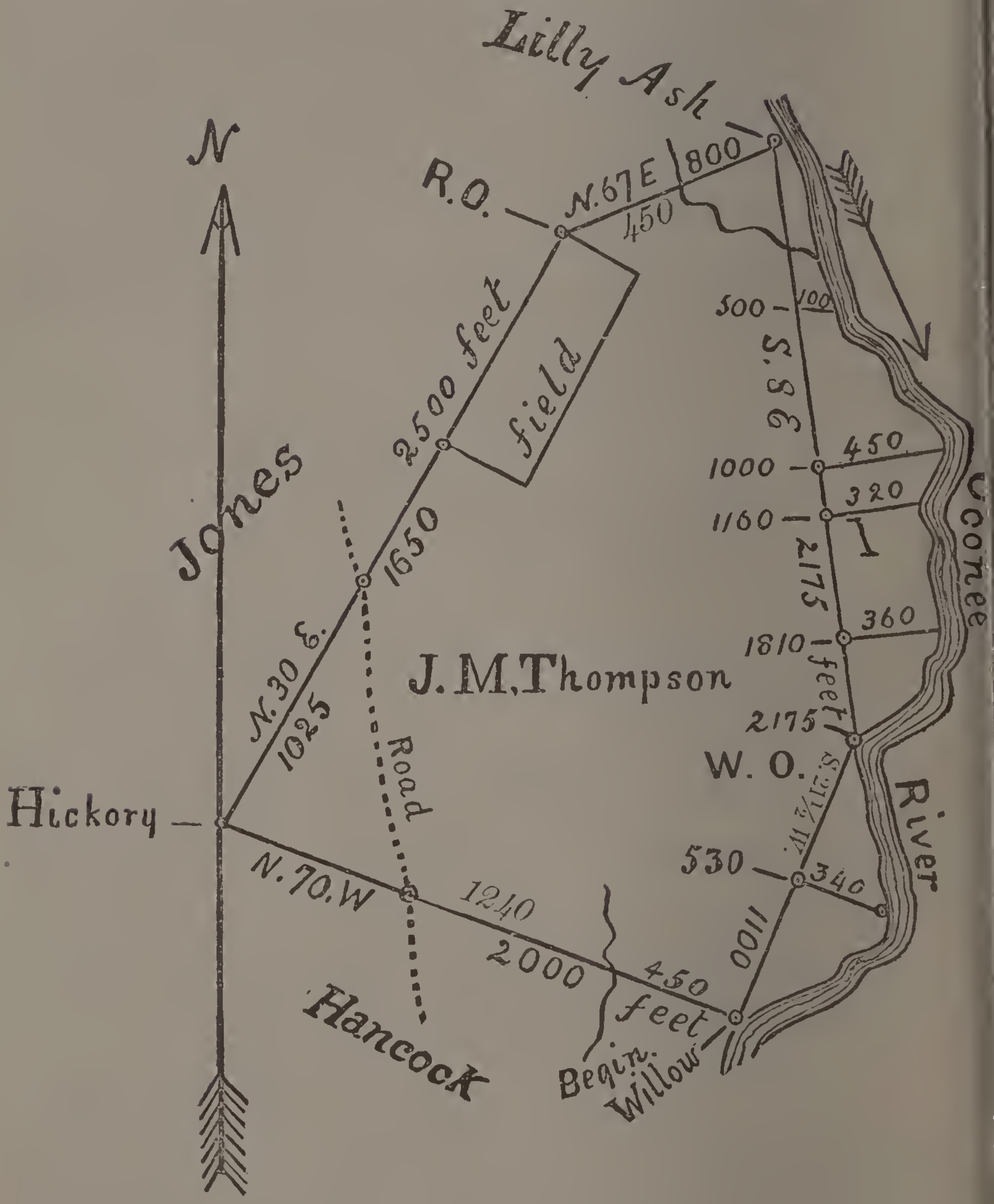
Thence N. 70 W. 450 feet to branch, 1240 feet to road, 2000 feet to Hickory.

Thence N. 30 E. 1025 feet to road, 1650 feet to field, 2500 feet to R. O.

Thence N. 67 E. 450 feet to branch, and 800 feet to Ash on river.

Thence down the river to beginning, as follows:

FIG. 32.



S. 8 E. 500 to offset, 100 to river, 1000 to offset, 450 to river.

1160 offset 320, 1810 offset 360, and 2175 to W. O. on river.

Then S. 21½ W. 530 feet to offset, 340 feet to river, and 1100 feet to Beginning Willow.

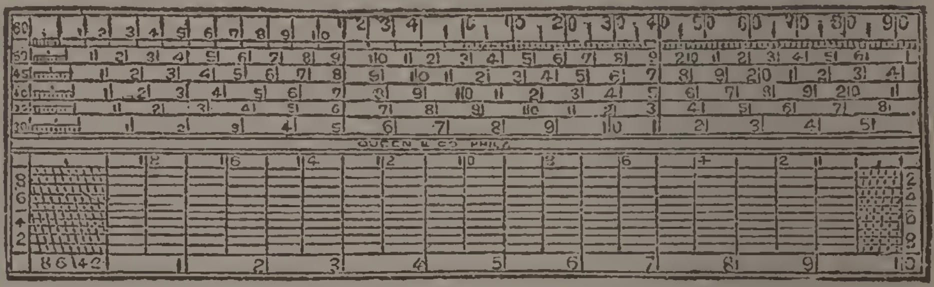
This example must suffice to teach the student how to run and record water or road lines when either is a boundary line. It is generally best to make a pencil-sketch or draft, and note the lines and offsets on all such boundaries. When the surveyor runs short chords or lines, it may be unnecessary to measure the distance to the stream at the various stations or points at which he curves. He can keep about the same distance from the stream, and note the distance to the larger curves, so that in mapping he can show them with sufficient precision. In taking field-notes, the surveyor can adopt his own method, and should do so as far as possible. In the above instructions the Author has given simple methods, easily understood and reduced to practice by the student.

CHAPTER IX.

PLATTING.

Platting the work is the nicest part of the duty of a surveyor, and he should not only study the various methods well, but also practise them a great deal, that he may become expert in this branch of the work. To be able to make a correct and handsome plat or map of his work is a strong recommendation to any surveyor. Since the estimates of the area depend entirely upon a correct plat or outline of the field-work, it becomes very necessary that great care should be exercised in platting. There are many methods taught in the extensive works on Surveying now extant, but the author will content himself in giving two plain practical methods, either of which the student will find easily reduced to practice.

FIG. 33.



The one is with a Protractor, and the other with a Scale of Chords.

It is not necessary to present the student with a minute

description of all the drawing instruments usually found in a case, as he will have them before him, and will readily perceive the use of each, or be instructed by his teacher.

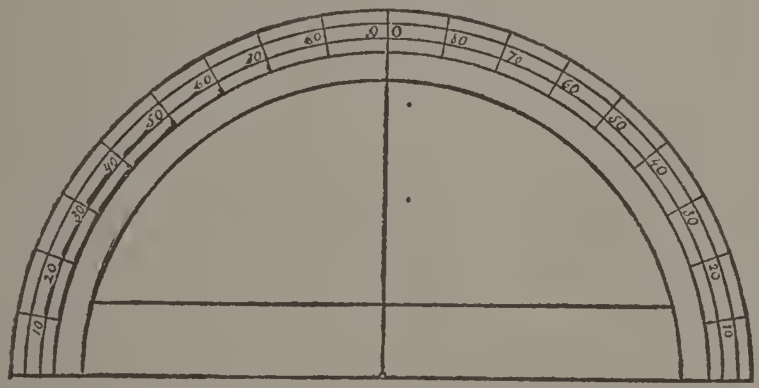
The instruments most commonly used in plain platting are the scale, protractor, and dividers or compasses.

The scale is of boxwood or ivory, generally six inches long, divided into inches and subdivision of inches, chains and tenths of chains on one side, and on the other a series of divisions numbered from 0 to 90, and marked C or CH. This is a scale of chords, and gives the length of the chords of any arc for a radius equal in length to the chord of 60 degrees of the scale.

THE PROTRACTOR.

A protractor is made of horn or brass, a semicircle divided into degrees and half degrees, numbered in both directions from 1 to 180, similar to the face of the com-

FIG. 34.



pass. It will be seen from the figure above that it has a straight side, the middle being marked by a notch, which is also the centre of the semicircle or semicircumference.

THE DIVIDERS.

The dividers are made of brass, and consist of two legs meeting at and revolving about a common joint or centre.

The principal use of this instrument is to lay off distances or lengths of lines to a certain scale. There are various

FIG. 35.

other instruments which are useful or handy in making plats, but the three mentioned above are the principal ones.

All plats and maps are made from a given meridian, and for convenience the top of the plat is considered north. A meridian is required for each corner, or angle, in the survey, and the angle of each course is set off by the dividers from the scale of chords, or protractor, and the length of each line by a scale of equal parts. These meridians, or parallels, may be set off by the dividers or a parallel rule; but the easiest, and perhaps the most accurate, plan is by means of a T square. It is simply a ruler let into a thicker piece of wood or stock at right angles to it. The stock is of uniform width and straight, so that either the side next the ruler or the opposite side may be used in setting off parallels. In using the T square, it is necessary to have a straight base line, as the edge of the paper, table, or mapping-board, or a line drawn at right angles to the meridian on the paper upon which the plat is to be made. It is then convenient to run the T square along it to different stations, and set off the parallels. If a straight-edged mapping-board is not convenient, a strip of plank with a straight edge may be fastened to any table with a smooth surface, along which the stock of the T square may be slipped to the different stations or angles.

Every surveyor should prepare a rectangular mapping-board or table sufficiently large for any size map, with each end at right angles with the sides. Then procure a correct **T** square with stem long enough to span the table, and he will find his platting easy, rapid, and correct. This is the method used by the Author.

TO PLAT WITH THE PROTRACTOR.

The paper is fastened to the table, and with the **T** square draw a meridian, having reference to the size of the plat and the side you desire to commence, so the plat will not run off the paper. At some convenient place on this meridian line make a dot, and enclose it with a small circle with the pencil, and from this as the starting corner, or first station, lay off the bearing of the first line with the protractor. With the dividers set off the length of the first line to any desired scale, and mark the end with a small dot, enclosing as before to show that it is a station. Through or immediately over this dot or mark draw another meridian, and with the protractor lay off the angle of the second line and set off the length, designating the station each time as above directed. Proceed with the remaining courses in the same manner, and when the last course and distance are platted, they should end precisely at the starting point, as the survey did. Should the plat not close or come together, some error exists either in the field-work or in the platting. It will generally be discovered where the error is by replatting carefully, or by making a reverse plat; that is, by platting in opposite direction to the one first used, reversing the courses. Sometimes it is necessary to plat from some other corner or station, in order to detect the error, which may be either in the bearing or in some measurement, or in both. The surveyor will never realize the importance of strict accuracy in the field-work until he attempts to plat his work, and after several efforts

utterly fails to make it close. The trouble is oftener in the measurements than anywhere else. The most careful chainmen will sometimes make mistakes in the *outs*, and report a line *five* chains longer or shorter than it is. Hence the trouble in platting the work.

Since it is not at all likely that errors have been made on all the lines, and that all the lines and bearings should be changed in the same proportion, it follows that no general rule can be made to fit each particular case. The surveyor having a full knowledge of the conditions under which the survey was made can readily tell what particular line is most likely to be wrong. He can then plat all the other lines and close on that one, when the error may be detected and the plat closed. In all cases where the plat does not close by a considerable discrepancy, a resurvey should be made.

TO CLOSE THE PLAT.

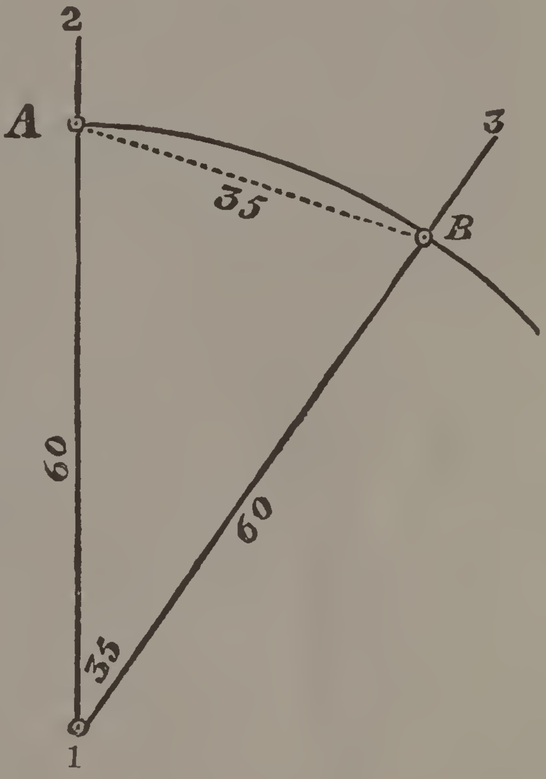
If it be assumed that the inaccuracy is to be distributed among all the lines in proportion to their length, then the following rule applies: Multiply the discrepancy by the length of the first line, and divide by the sum of all the lines. The quotient will give the distance the second corner or station is to be in or out. Then multiply the discrepancy by the sum of the first and second lines, and divide the product by the same sum of all the sides, and the quotient will show the distance to move the third station. So on for any line desired. Add the line to all the preceding lines, and multiply the sum by the discrepancy, and divide as before; the quotient will show how much the corner is to be moved in or out.

TO PLAT WITH A SCALE OF CHORDS.

Draw an indefinite line, as from 1 to 2, and from the scale of chords open the dividers from zero, or 0, to 60,

set one leg at 1, and describe the arc A B of sufficient length for the angle. Take the distance, 35, on the same scale of chords, set one leg of the dividers at A, and make the point B on the arc A B, and with the ruler describe the line from 1 to 3. The angle of 35 degrees is set off from the meridian 1 to 2.

FIG. 36.



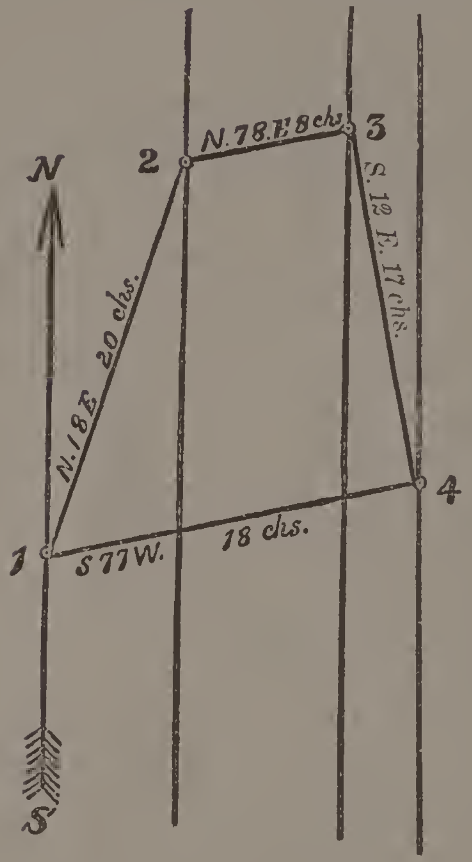
If it be desired to produce another line from B, draw a meridian through B parallel to 1 and 2; then with the dividers describe the arc of 60 degrees, as before, either north or south as required, and on the east or west side of the meridian, and then set off the degrees desired, making a station on the arc. Draw a line from B through this station, and the desired angle is set off from B. If the student desires to produce a plat by this method, he must define the length of each line by the dividers to any scale he may choose. Proceed as above described with each succeeding line to the beginning corner. One example, with minute instructions, will suffice to teach this lesson by both methods of platting.

WITH THE SCALE OF CHORDS.

Draw the meridian marked N and S. From the scale of chords open the dividers to 60 degrees, and from 1 describe an arc on the east side of the meridian N S from the north end, since the bearing is to the northeast. Now open the dividers to 18, and set off the bearing of line 1 and 2, and with the ruler draw the line long enough to get

the net length, 20 chains. Take a common square, or any rule with inches, from which take the length of the line to

FIG. 37.



Scale—10 *chains to* 1 *inch.*

any scale, as 10 or 20 chains to the inch, and designate the end by a station mark ⊙ at 2. Through the station 2 draw a parallel meridian, and on the north end and east side draw the arc of 60 degrees, setting one leg of the dividers at 2. Then from your scale get 8 chains, and mark station 3. Another parallel is drawn, and the arc 60 degrees described on the southeast side from 3. The angle of 12 degrees is defined on this arc, and the line 3 to 4 drawn. The length, 17 chains, is taken from the scale, and station 4 made. Through 4 the last parallel is drawn, and the arc of 60 degrees on the southwest side, since the direction of the line is southwest. The angle, 77 degrees, set off and the line from 4 through 1 drawn.

Now get 18 chains from the scale, and the plat is closed at 1, the beginning corner.

To make the same plat with the protractor.

With the T square draw the meridian N S, and make a station ⊙ on it. Lay the protractor on the meridian, on the east side, so that the notch on the straight side will be at 1. With some sharp-pointed instrument make a dot at 18 degrees, and from 1 draw the first line through this dot or point. Take 20 chains from the scale with the dividers and make station 2. Bring the T square up to 2 and draw the second parallel, and lay the protractor at 2 on the east side, and mark the point at 78 degrees from the north side. Draw this line from 2 and set off 8 chains, and mark 3. Move up the T square to 3 and draw the third parallel. With the protractor at 3, as before directed, make a point at 12 degrees from the south side, as the course is to the southeast. Draw the line from 3 over this point and set off 17 chains, and mark 4. Slide the T square up to 4 and draw the last parallel. Now lay the protractor on the west side of it, with notch at 4. Designate 77 degrees by a small dot from the south side, and make a line from 4 over 1. Get 18 chains with the dividers, the length from 4 to 1, and the plat is finished.

As before remarked, this is the most rapid, and at the same time the most accurate, method of platting, and is the one used by the Author.

5 *

CHAPTER X.

CALCULATING THE AREA.

The principles taught in this chapter are purely arithmetical, and the Author presumes the student is well posted on common arithmetic before he attempts the study of surveying. It is true that the rules for calculating the area of surfaces are based upon geometry and trigonometry, yet they may be applied, as we shall do in this work, arithmetically; so when the student learns these principles from his arithmetic, he can apply them in his surveying. Since getting the area of almost any shaped plat is simply calculating so many squares, rectangles, triangles, circles, or parts of circles, it follows that the principles applicable to these figures are as easily applied in one place as another, in one study as another, and are the same wherever found.

Area is the contents of the surface expressed in square inches, feet, yards, rods, chains, acres, or miles.

The acre is the common unit of measure for land, and is equal to a rectangle 10 chains long and 1 chain wide, or 160 rods long and 1 rod wide, or 4840 yards long and 1 yard wide, or 43,560 feet long and 1 foot wide. A rood is one-quarter of an acre, and contains 40 square rods. A rod is called a perch.

Land is generally measured in acres. The fractions of an acre may be expressed in roods and rods, but the most convenient way of expressing them is in *tenths*.

If the student will procure a copy of Caldwell's Arithmetic, and carefully study the first fourteen pages under the head of Mensuration, page 132, he will find it remarkably easy to master this chapter of his surveying. The principles there taught and the figures used are the same we shall employ here. We shall need only a few additional figures and instructions.

To find the area of a square, rectangle, rhombus, and rhomboid.

FIG. 38.

FIG. 39.

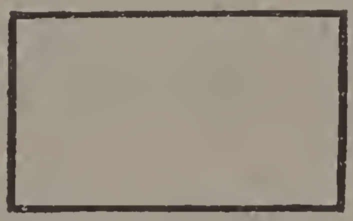


FIG. 40.

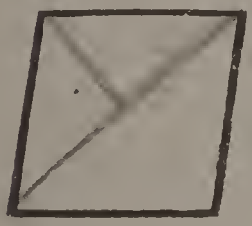
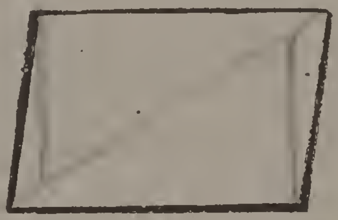


FIG. 41.



RULE.

Multiply the length by the perpendicular distance between the opposite sides, or the base by the altitude.

1. A field is 22 chains square. How many square chains in the area? Ans. 484 square chains.

2. A field is 14 chains long and 8 chains wide. What is the area? Ans. 112 square chains.

3. A rhomboid is 31 rods long and 26 rods across. What is the area? Ans. 806 square rods.

4. What is the area of a rhombus 30 rods long and perpendicular distance 28 rods? Ans. 5.2 acres.

5. A field, 534 yards long and 438 yards wide, has what area? Ans. 233,892 square yards.

6. A cotton field is 90 yards long and 85 yards wide. How many square yards in the field?

Ans. 7650 square yards.

To reduce such questions to acres, divide by the number of each measure in one acre; the quotient will give the acres, and by annexing one cipher to the remainder and continuing the division, we have *tenths*. Thus, in question 5 above, we divide 233,892 square yards by 4840, the number of square yards in one acre. The quotient is 48 acres and three-tenths, with a small remainder.

Ans. 48.3 acres.

So in question 3, divide 806 by 160, the number of square rods in one acre. Ans. 5 acres.

I will give the common table of

SQUARE MEASURE.

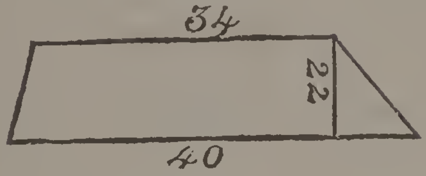
144	square inches	make	1 square foot, sq. ft.
9	square feet	"	1 square yard, sq. yd.
30¼	square yards	"	1 square rod, sq. rd.
40	square rods	"	1 square rood, R.
4	square roods	"	1 square acre, A.
4840	square yards	"	1 acre.
160	square rods	"	1 acre.
10	square chains	"	1 acre.
43,560	square feet	"	1 acre.
640	acres	"	1 square mile.

NOTE.—For practical exercise, 70 yards square may be considered an acre, though not strictly correct. As, for example, where land is stepped off instead of being measured.

By the above table the contents of land are calculated.

To find the area of a trapezoid.

FIG. 42.



RULE.

Multiply half the sum of the parallel sides by the altitude, and the product is the area.—(*Caldwell's Arithmetic*, p. 139.)

1. A farm is 40 chains on one side, the opposite side 34 chains, and 22 chains across. What is the area?

$$40 + 34 = 74 \div 2 = 37 \times 22 = 814 \text{ sq. ch.}$$

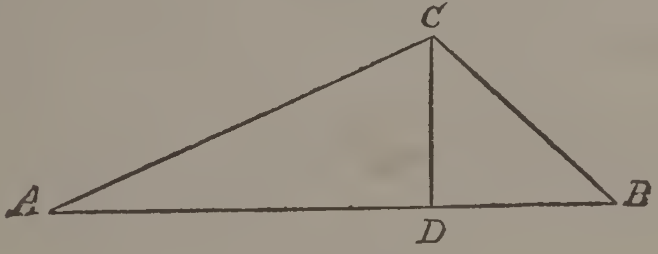
2. What are the contents, when the parallel sides are 800 yards and 500 yards and the distance across 700 yards?

Ans. 94 + A.

3. Two sides of a trapezoid are 280 feet and 234 feet, and the altitude or distance across is 185 feet. What is the area? Ans. 47,545 sq. ft.

To get the area of a triangle.

FIG. 43.



RULE.

Multiply the base by the altitude and half the product, or multiply the base by half the altitude.—(*Caldwell's Arithmetic*, p. 140.)

1. A triangle has a base of 40 chains and altitude 15 chains? What is the area? Ans. 300 sq. chs.

To reduce the 300 chains to acres, divide by 10, the number of square chains in an acre. Ans. 30 A.

2. What is the area of a triangle with base of 140 rods and altitude of 90 rods? Ans. 6300 sq. rds.

Divide the 6300 by 160, and we have 39.3 A.

3. A field of triangular shape has a base of 1500 feet and an altitude of 400 feet. What is the area?

Ans. 300,000 sq. ft. = 6.8 A.

4. What is the area of a triangle whose base is 24 chains, 14 links, and altitude 13 chains, 84 links?

Ans. 16.7 A.

By triangles most of land is calculated. The plat is divided into triangles by diagonal lines drawn from opposite corners, or from some point to opposite angles, so as not to intersect each other, and the several triangles thus formed calculated by the rule above given, the sum of which will be the area of the whole figure or plat. The correctness of this method depends upon the accuracy of the plat and on its scale, which should be as large as possible. A little practice will suggest the best way to draw the diagonals. These should be drawn so as to form as few triangles as possible.

To find the area of a trapezium.

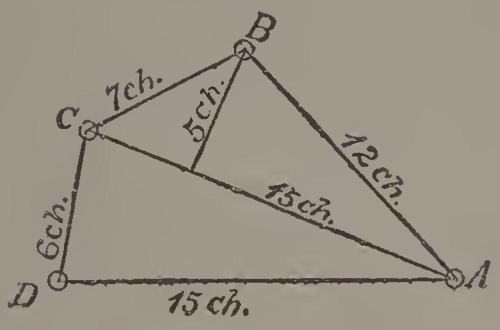
RULE.

Divide the figure into two triangles by a diagonal drawn from two opposite angles. Find the area of each triangle and add them together: the sum will be the area.

A very gross error is often committed as to a trapezium

by taking the average or half sum of the two opposite sides and multiplying them together for the area. That

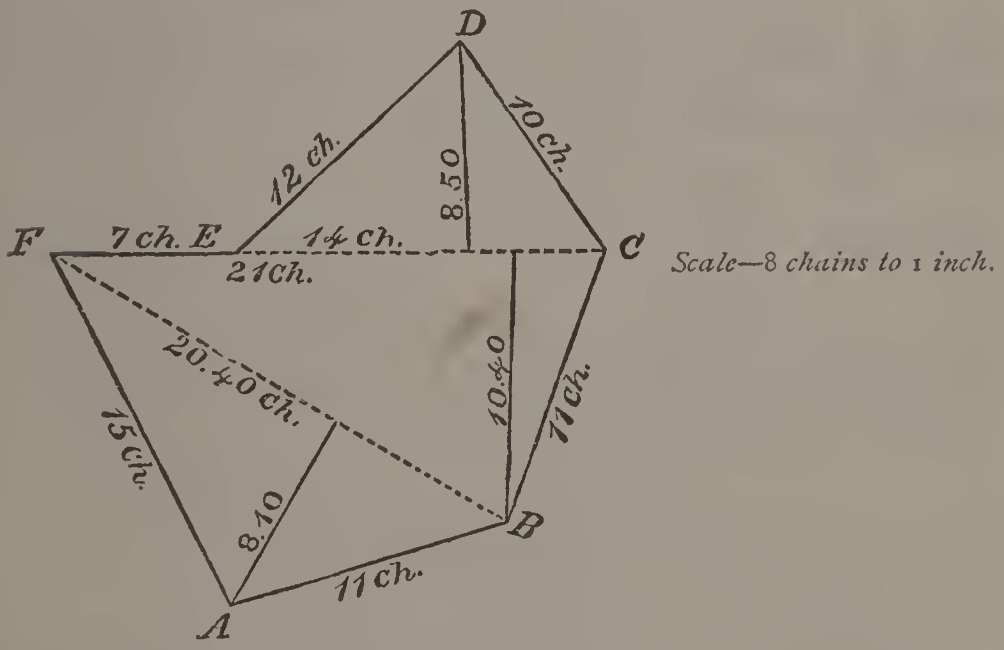
FIG. 44.



assumes the trapezium to be equivalent to a rectangle, with these averages for sides.

To find the area of a figure having more than four sides.

FIG. 45.



RULE.

Divide the plat or figure into triangles by diagonals ; find the area of each of the triangles, and add them together; this sum will be the area of the whole plat.

This is the method most commonly used by surveyors for calculating the area of their plats. It is easy, simple, and practical; but, like every other department of the work, great care should be exercised in the use of the scale in determining the length of lines, diagonals, and altitudes. A slight excess or deficiency in the length of either will make an error in the area, and, indeed, may be very fatal to the work. The careless use of the scale and dividers, with the difference in scales, make the main difference in results by different surveyors. Hence, two surveyors will run the same piece of land, plat and estimate it, and the results will differ slightly.

Take figure on page 59, above, and apply the rule.

There are three triangles, A B F, B C F, and C D E. The first, A B F, has a base of 20 chains and 40 links and an altitude of 8 chains and 10 links.

$$20.40 \times 8.10 \div 2 = 82.62.$$

The second, B C F, has a base line of 21 chains and an altitude of 10 chains and 40 links.

$$21 \times 10.40 \div 2 = 109.20.$$

The third, C D E, has a base of 14 chains, altitude 8.50.

$$14 \times 8.50 \div 2 = 59.50.$$

Add all these several areas together, and we have

$$\begin{array}{r} 82.62 \\ 109.20 \\ 59.50 \\ \hline 251.32 \end{array}$$

251 chains and 32 links.

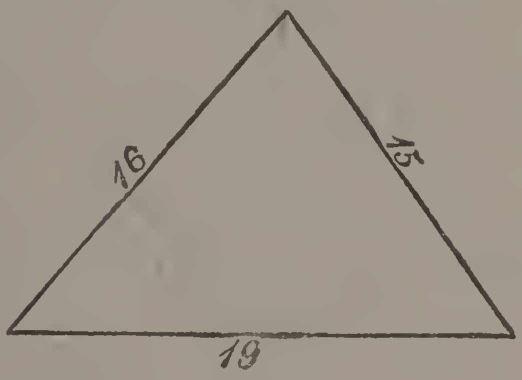
Reduce to acres by dividing by 10. Ans. 25.1 A.

This example fully represents the method of calculating the area of any plat having many sides and angles. It is

always best, however, to divide the plat into triangles from some other angles, and estimate the area again; then, by adding the two results together and halving, get the true area.

To find the area of a triangle when the length of each side is known.

FIG. 46.



RULE.

Add the three sides together and half the sum. From this half sum subtract each side. Then multiply the half sum and three remainders together, and extract the square root of the product, and the result will be the area.

Take figure above.

The sum of the three sides is 50, half of it 25. From 25 subtract each side, and 6, 9, and 10 are the remainders. Multiply 25 by these numbers, and the product is 13,500, the square root of which is 116, the area.

1. The sides of a triangular farm are 40, 60, and 74 chains. What is the area? Ans. 119.8 A.

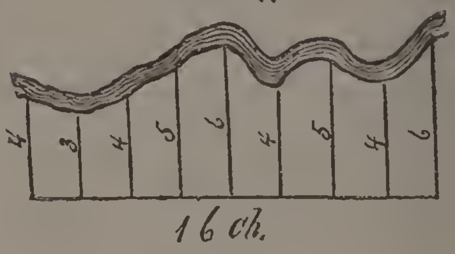
To get the area of several offsets having a straight base line.

RULE.

Add the first and last lines, or two outside lines, and take half the sum. To this half sum add all the other lines,

and multiply the sum by one of the equal distances between the offsets, or divide the sum by the number of offsets, less

FIG. 47.



one, and multiply this quotient by the whole length of the base line.

Take figure above, and apply both methods.

Add 4 and 6, the two outside lines, and half it gives 5. To 5 add 3, 4, 5, 6, 4, 5, and 4 gives 36.

It will be observed that there are 8 spaces between offsets; the base line 16 is divided by 8 = 2. Now multiply 36 by 2, and we have 72 chains, or 7.2 A.

By the second method divide the 36 by 8, the quotient $4\frac{1}{2}$ shows the average width of the rectangle, whose length is 16 chains. Multiply 16 by $4\frac{1}{2}$, and we have the same result as above.

The base line of an irregular field is 44 chains, and its breadths at five equidistant points are 8, 10, 9, 14, and 20 chains. What is the area?

Ans. 517 chains = 51.7 A.

CIRCLES.

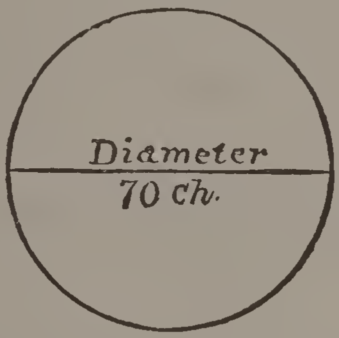
To find the area of a piece of land in the form of a circle.

RULE.

Square the diameter and multiply the square by .7854, and point off four figures from the right, or multiply the square of the diameter by 11 and divide by 14.—(*Caldwell's Arithmetic*, page 143.)

The diameter is squared to give the area of a square figure of the same size, and, as the area of a circle is less than it, we multiply the area of the square (the square of the diameter) by .7854, which deducts .2146 for the corners of the square, and leaves the area of the circle.—(*Caldwell's Arithmetic*, page 143.)

FIG. 48.



1. A circular farm is 70 chains in diameter. How many acres in it? Ans. 384.8 A.

.7854	70
4900	70
7068600	4900
31416	11
10)3848.4600	14)53900
384.8 A.	385.0

The student will observe a slight difference in the results by the two methods. Quite as large a class of mathematicians use $\frac{11}{14}$ as use .7854. The Author prefers the use of $\frac{11}{14}$, but leaves the student to choose for himself.

2. A circular piece of woods is 40 rods in diameter. How many acres? Ans. $7\frac{6}{7}$ A.

3. A tract of land is 1 mile in diameter. How many acres does it contain? Ans. 502 + A.

The area being given, to find the diameter.

RULE.

Divide the area by .7854, or $\frac{11}{14}$, and the quotient will be the square of the diameter. Then extract the square root of that number, and you have the diameter.

Since the area of a circle is obtained by squaring the diameter and multiplying it by .7854, it follows, to reverse the operation, divide the area by .7854 and extract the square root, we have the diameter.—(*Caldwell's Arithmetic*, page 125, question 7.)

1. I have a circular meadow containing 2464 square yards. What is the diameter? Ans. 56 yards.

```
.7854)2464.0000(√31.37
      23562
      -----
       10780
        7854
       -----
        29260
        23562
        -----
         56980
         54978
         -----
          2002
```

2. What is the diameter of a circular tract of land whose area is 5544 square rods? Ans. 84 rods.

3. The area of a circular tract of land is $31\frac{3}{7}$ acres. What is the diameter in rods? Ans. 80 rods.

To find the area of an ellipse.

RULE.

Multiply the two diameters together, and that product by .7854.

FIG. 49.

1. What is the area of an elliptical piece of ground whose transverse axis is 8 chains and the conjugate axis 4 chains? Ans. 2.5 A.

$$\begin{array}{r} 8 \\ 4 \\ \hline 32 \end{array} \qquad\qquad \begin{array}{r} .7854 \\ 32 \\ \hline 15708 \\ 23562 \\ \hline 10)25.1328 \\ \hline 2.5 \end{array}$$

2. An elliptical farm is 140 rods one way and 72 rods the other. How many acres? Ans. $49\frac{1}{2}$ A.

To estimate land by stepping its lines.

It is assumed that a man can step a yard at a step, and that 70 steps square is 1 acre. It is therefore very convenient for farmers to estimate their fields by stepping. But while it is very useful to the farmer, it is only an approximation. Any of the figures given in the preceding pages may be roughly estimated by steps as directed for measurements, remembering to divide by 70 twice.

For example, for square or oblong fields step the side and end, multiply the two numbers together, and divide by 70 twice, and the result will be acres.

1. A farmer has a cotton field 210 steps long and 150 steps wide. How many acres? Ans. $6\frac{3}{7}$ A.

$$\begin{array}{r}
210 \\
150 \\
\hline
10500 \\
210 \\
\hline
70)\,31500 \\
\hline
70)\,450 \\
\hline
6\frac{3}{7}
\end{array}$$

2. A corn patch is 140 steps square. How many acres?

Ans. 4 A.

3. A piece of land is stepped off 280 steps one way and 260 steps the other? How many acres?

Ans. $14\frac{6}{7}$ A.

CHAPTER XI.

DIVIDING LANDS.

The surveyor is required to lay off land into so many different shapes and proportions, it is difficult to give a rule or rules applicable to all cases. The business of dividing land must therefore be left in a great measure to the skill and judgment of the surveyor, who, if he is posted on trigonometry sufficiently to understand getting the area of different shaped figures, will not find it difficult, after a little practice, to divide up lands as he shall be required. It is generally best to have an accurate plat of the land before him, so he can see how dividing lines are to be drawn to cut off the portion desired. It is always necessary to know the length of bounding lines so as to make the proper calculations of the desired lines, knowing the area wanted. Only a few rules and examples will be given for the general instruction of the student.

PROBLEM I.

A SQUARE.

To lay off a square.

RULE.

Reduce the area to chains, rods, or feet, extract the square root, and the result will be the length of one side. Then proceed with the compass and chain to produce the square on the land from the base line and starting corner.

1. What is the length in chains of a side of a 40 acre field? Ans. 20 chs.

```
   40
   10
  ----
√400(20 chains
   4
  ----
   00
```

2. It is desired to lay off 60 acres in a square; what is the length of a side in rods? Ans. 98 rds., nearly.

3. A piece of land in a square contains 15 acres. How long is each side in feet? Ans. 808.3 ft.

PROBLEM II.

A RECTANGLE.

Having one side and the given area, to find the other side.

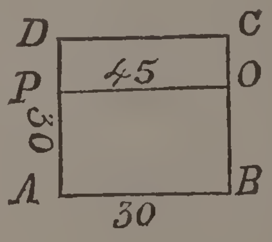
RULE.

Reduce the given area to the same denomination of the given side, and divide that number by the length of the given side. Then trace the rectangle on the ground.

1. A tract of land is 30 chains square; it is desired to cut off 45 acres across one side. How long is the other side? Ans. 15 chains.

FIG. 50.

```
    45
    10
   ----
30)450
   ----
    15
```



To produce it with a compass, measure from D, 15 chains, to P; then run the line P O parallel to D C, and 45 acres are cut off.

2. A base line is 968 feet long, and 8 acres are to be laid off in a rectangle. How far down the side will be required? Ans. 360 feet.

3. A field is 110 yards long, and contains one-half an acre. How wide is it? Ans. 22 yds.

PROBLEM III.

A TRIANGLE.

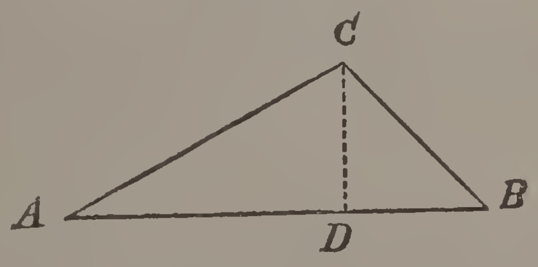
To cut off a given number of acres by a line from any angle of a triangle.

Get the length of the side opposite the angle from which the dividing line is to be drawn.

RULE.

Multiply the base line by the number of acres to be cut off, and divide by the whole area of the triangle; the quotient will be the length to be laid on the base.

FIG. 51.



1. The triangle, Fig. 51, contains 24 acres. It is required to cut off 9 acres from B. How far on the base line A B, which is 40 chains long, must be measured?

Ans. 15 chains.

$$\begin{array}{r} 40 \\ 9 \\ \hline 24)360 \\ \hline 15 \text{ chains.} \end{array}$$

Now measure 15 chains from B to D, and produce the line to C, and the triangle B C D contains 9 acres.

PROBLEM IV.

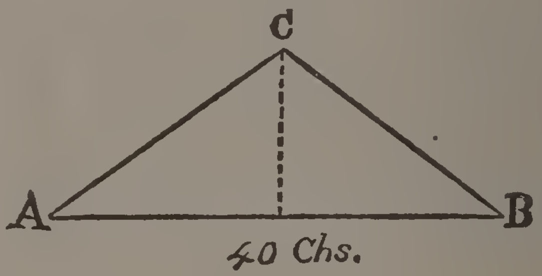
To lay off a triangle to contain a given number of acres from a certain base.

RULE.

Double the area required, reduce it to the same denomination as the base, and divide by the base. Or, which is the same, divide the area by half the base or half the perpendicular.

The student will perceive, since a triangle is *half* a square, the base or perpendicular must be as long again to embrace the same amount of area.

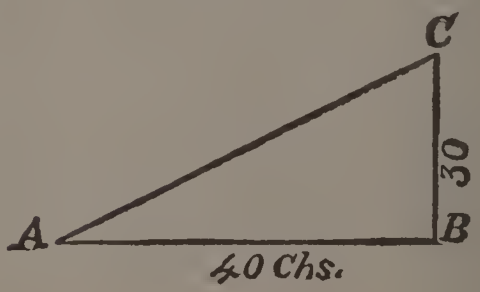
FIG. 52.



1. Lay off a triangle to contain 60 acres on a base of 40 chains.

$$\begin{array}{r} 60 \\ 10 \\ \hline 40 \div 2 = 20)\overline{600} \\ \hline 30 \end{array}$$

FIG. 53.



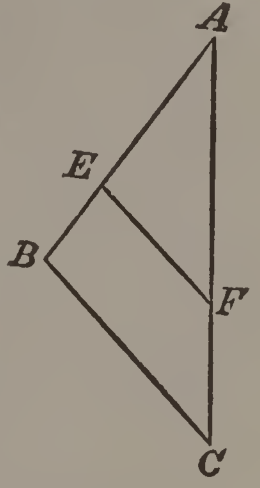
To lay this triangle with a compass and chain, produce the base, 40 chains, from A to B, and at right angles, or as required, produce the altitude, 30 chains, and by running a line from C to A (Fig. 53), or the two lines, A C and C B, in Fig. 52, the triangle is complete.

2. It is desired to produce a triangle containing 35 acres on a base of 2635 feet. What is the altitude?

Ans. 1157 feet.

Again, it may be required to cut off a certain number of acres from a given triangle by a line parallel to the base.

FIG. 54.



Let A B C be a triangle containing 50 acres, and the surveyor is required to run a line parallel to B C, which will cut off *one-half* of the area, or 25 acres, leaving 25 in the triangle A E F. Square the side A B and multiply by 25, and divide by 50, and this will give the square of A E. Extract the square root of this result, and it will give the length of A E. Measure from A to E a distance equal to this, and run E F with the same bearing as B C. Then E F C B will contain 25 acres.

RULE.

Multiply the area to *be left out* (A E F) by the square of either one of the sides which meet the side to which it is desired to run parallel, and divide by the whole area; then extract the square root of the result. This gives the distance to be measured on the side whose square was taken. This distance, measured from the vertex of the triangle or (angle opposite the side to which it is desired to run parallel) on the side *squared*, will mark the point from which a line with the same bearing as the base will cut off the amount to be left out in the triangle above, leaving the

desired area between that line and the base. To illustrate:

Suppose the triangle contains 100 acres, and it is required to cut off $\frac{1}{3}$, or $33\frac{1}{3}$ acres, next to the base. Then there will be left $66\frac{2}{3}$ acres in the triangle. This *last area* is what must be multiplied by the square of one of the sides. It makes no difference what be the part desired to be cut off, the same principle applies. If $\frac{1}{5}$ of the area is to be cut off, then $\frac{4}{5}$ will be left in the triangle, and this is what must be multiplied by the *square* of one of the sides of the whole triangle and divided by the whole area, in order to get the square of the distance from the vertex to the point from which the parallel line must be run.

A great many examples and problems might be given under the head of dividing lands, but it is thought those given are entirely sufficient, especially since it is more the province of practical surveying to trace lines and lay out the land after the shape and area have been determined than to solve questions.

CHAPTER XII.

SURVEYING BY TANGENTS.

BY

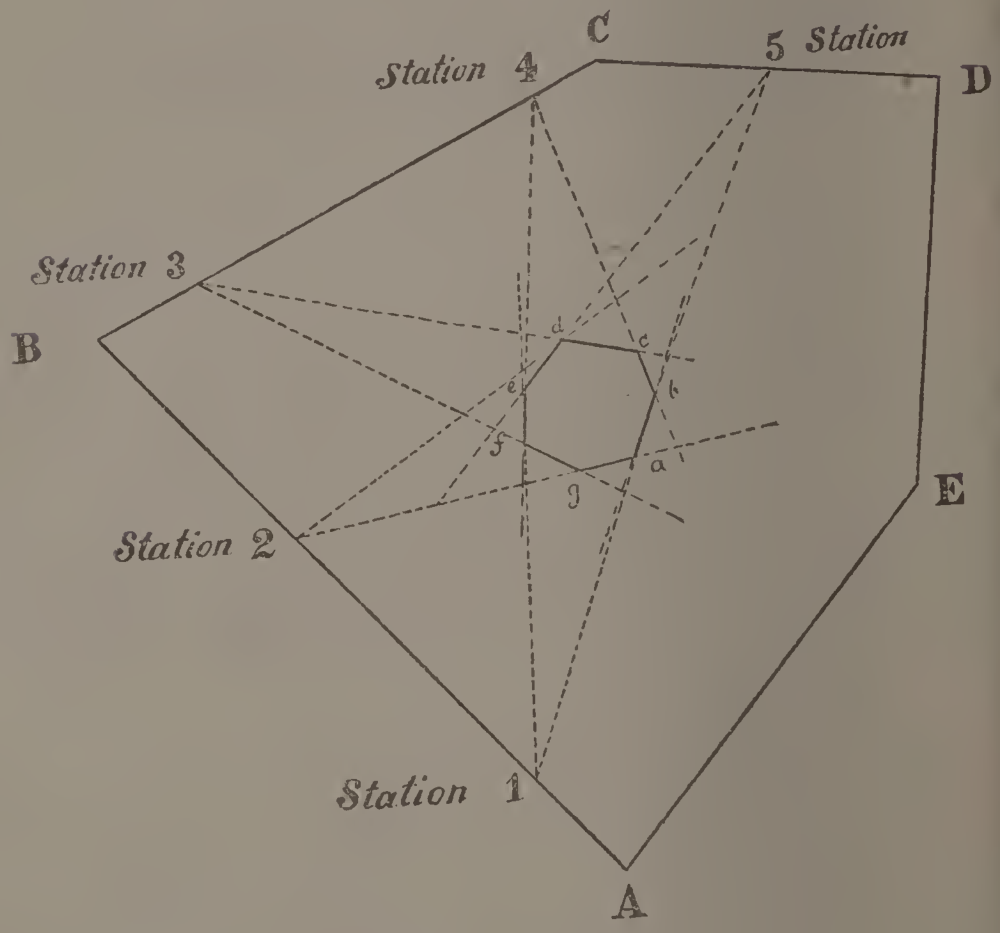
PROF. WILLIAMS RUTHERFORD, A.M.

The surveyor is sometimes required to determine the exact amount of *cleared land* on a plantation. In some fields are frequently found rocky knolls, ponds, or marshy ground, which are unfit for cultivation, and therefore left uncleared. To survey all such places separately and deduct them from the field would require a great deal of labor and time. The following method has been adopted, which saves a great deal of time, and therefore expense, to the owner of the land.

While running around the field, whenever the spot to be left out can be clearly seen, note the distance to the point of observation and take *two bearings*, one to the extreme right and the other to the extreme left, of the spot which it is desired to exclude from the survey. At several points on *each line* around the field take the same observations, being careful to note the object or objects by their numbers (as there may be several in the field), as well as the distance to each point of observation and the *bearing* of the two tangent lines. When the field has been run around and is to be platted, first lay down the *outside lines* as though none of its area was to be excluded. Then with your scale lay off the bearings from each station,

and draw dotted lines through the entire field. These tangent lines will intersect each other on the edge of the pond or knoll, and will mark it out in the right place. The area can be estimated and deducted from the whole area included by the outside lines.

FIG. 55.



Let A B C D E be a field in which there is a marsh or pond, *a b c d e f g*, which it is desired to exclude or leave out from the area of the field, in order to get the exact amount of cleared land. Measure from A to station 1. Then take two bearings to edge of pond or marsh, 1 *a* and 1 *f*. Measure on to station 2 and take two more bearings, 2 *g* and 2 *e*. Take the whole length of A B as usual. Measure from B to station 3 and take two bearings, 3 *f* and 3 *d*. Then measure to station 4 and take two other

bearings, 4 *e* and 4 *c*. Finish the whole line B C. From C measure to station 5 and take two bearings, 5 *d* and 5 *b*. If these bearings will not enclose the pond as accurately as desired, continue to take other bearings from points on lines D E and E A. Where these tangent lines cross each other at *a b c d e f g*, make dots and calculate area enclosed by figure thus marked out. It will be seen that no measurements are necessary with the chain, and the only time lost is the time it may require to take the bearings from each station and record them.

CHAPTER XIII.

ALTITUDES AND HEIGHTS.

Taking the Altitudes or Heights of Objects without Instruments for taking Angles.

To find the height of a tree or other object which casts a shadow on a clear day.

Drive a stake perpendicular to the level ground, measure its shadow and the shadow of the tree or other object. The length of the shadow of the stake is to its length as the length of the shadow of the tree is to the height of the tree.

RULE.

Multiply length of stake by length of shadow of tree, and divide by length of stake; the quotient will be the height of tree.

If the sun is not shining so as to cast a shadow, then *this* method may be adopted: Drive a stake about seven or eight feet high, so that the observation can be more easily made. Tack a lath with a shingle nail to stake a little above your head, so that you will have half the lath on each side of the stake; point this one to the top of the object. Nail another lath below the first, so that when the two ends next to your eye are brought together, it will be directed to the *foot* of the object. Measure the distance between the two *nails* and the distance from your eye

(where the two laths cross) along the *lower* lath to the upright stake; also, the distance from the eye to the object. Then the distance from the eye to the stake is to the distance between the nails as the distance to the object is to the height of object.

FIG. 56.

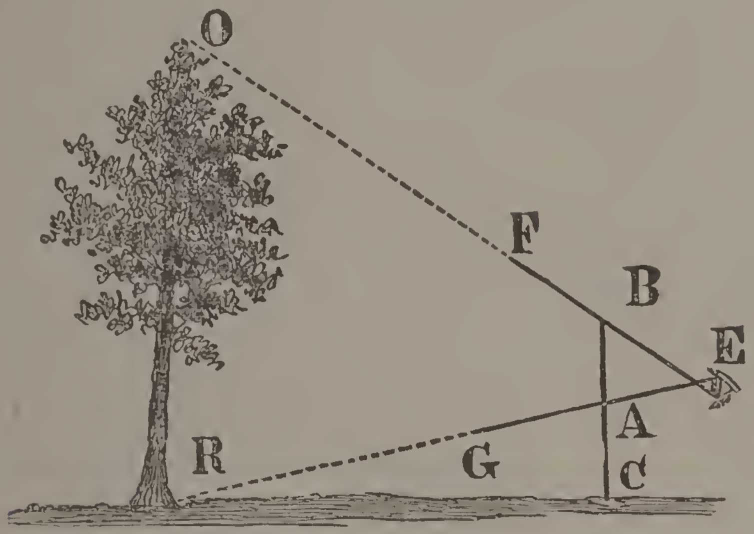


ILLUSTRATION OF TAKING HEIGHTS OF TREES OR OTHER OBJECTS.

Let B C be the stake stuck at right *angles to the level ground.* Let E F and E G be two ordinary laths nailed to stake B C at points B and A. Let the lath E F be directed to *top*, and lath E G to *bottom* of the tree. Measure E A and B A and E R

Then E A : B A : : E R : O R.

RULE.

Multiply the distance from the eye to the foot of the object by the distance *between the nails*, and divide by the distance from the eye to the *bottom nail;* the quotient will be the height of the tree. All the measurements must be taken in *inches*, and then the final result reduced to feet.

This chapter, while it perhaps illustrates no principle of surveying, is inserted for the practical benefit of the student

and reader. With it the surveying is closed, and the author pleads that the rules, methods, and instructions are purely practical, and intended to form a hand-book on surveying that may be mastered in a few weeks by the student who is posted in common arithmetic.

It is the book that should follow Caldwell's Practical Arithmetic in the schools or out of them, and the student will find both simple, plain, and easy, and the shortest method ever published.

In the Appendix, which follows, are some valuable matters, and should be carefully perused by all into whose hands this book falls. For the first time the reason *why* the magnetic needle stands north is published. It has always been a hidden mystery, but is now explained by that wonderful scientist, Dr. Means, of Oxford, Georgia. This chapter alone is worth the price of the book.

While the laws given in the Appendix relative to county surveyors are Georgia laws, the same principles bear on the duties of legal surveyors throughout the country, and are similar in all the States. The "Texas Land Surveying," from a skilful Texas surveyor, is richly worth a dozen books.

TERRESTRIAL MAGNETISM.

POLARITY OF THE MAGNETIC NEEDLE.

BY

ALEXANDER MEANS, M. D., D. D., LL. D.

OXFORD, GEORGIA.

Having been requested to furnish for this work an article explanatory of the Polarity of the Magnetic Needle, and an answer to the popular inquiry—"Why does its arrow-head always point to the North?" this abbreviated essay is respectfully submitted. Magnetism, as it is now understood by the Scientific world, is a subject of profound and growing interest to the Chemist, the Philosopher, the Astronomer, the Navigator, the Magnetical and Telegraph Instrument Maker, and School Teacher. Its facts and phenomena, as discovered and traced within the last half century, give it a commanding position among those subtile, elementary forces which have within that period already revolutionized the commercial world, and which are now rapidly pushing their conquests into the hitherto retired and circumscribed domain of domestic and social life. Indeed, it is ascertained to be an ethereal medium of great power, activity and cosmical reign, not being confined in its manifestations to this earth alone—the sun himself—the great focal center of the system, giving palpable evidence of employing its agency in the production of signal results to be found in the planets and their satellites which revolve around him. A brief sketch of the history and modern progress of this Science, is all that circumstances will justify. The simple fact, then, of the *attractive force* of the

native Magnet, or Loadstone, which consists generally of the pro-toxide or black oxide of iron, was unquestionably known to Aristotle, 380 B. C.—to Pythagoras, 500 B. C., and to the great Grecian Bard, Homer, about 900 B. C.—but its property of polarization was not discovered until the twelfth century of the Christian era. Mr. Gilbert, of England, however, at the beginning of the seventeenth century (1600 A. D.) was the first to advance the bold hypothesis that our earth was a great magnet, having its greatest intensity at the two terrestrial poles, or the opposite "termini" of the ideal axis on which the earth revolves. The *dipping* of the Magnetic Needle, in advancing from the Equator to the Poles, was afterwards attributed to the supposed existence of a small magnet in the earth's interior. It was subsequently suggested, however, by Tobias Mayer, that there must be two small magnetic bodies, so located in the body of the planet as to produce this remarkable result.

About the year 1825, Ampere, of France, taught that the whole globe was magnetic, and that the intensity at the Poles, was the resultant of all the magnetic forces existing among its particles or molecules. He was also the first to maintain that electrical currents passing around the earth, would rationally account for all magnetic phenomena. This succinct historical review of our Science must suffice for the purposes intended. We must now deal in more reliable data and more recent discoveries, and from these, according to Lord Bacon's system of inductive philosophy, reasoning from ascertained and classified facts, to theories, and which is now universally adopted by all Scientists—we feel warranted to present the following satisfactory explanation of Terrestrial Magnetism, and consequently of the phenomena connected with the movements of the Magnetic Needle. And here, allow us to premise, that to furnish a clear and satisfactory exposition of Terrestrial

Magnetism, its sources, its modes of action and its consequences would authorize an elaborate treatise at the hands of the writer. Nor would this be sufficient for the uninitiated, without the aid of diagrams or engravings, and the employment of a good Galvanic Battery with appropriate appendages, such as Magnets, Helices, a small artificial globe, etc., etc. In supplying this article, however, for the student's eye, our time, space and resources are all limited. We shall, therefore, attempt to simplify and condense, as far as practicable, leaving further demonstrations to the teacher.

From the stand point occupied by modern Science it may now be enunciated that *Light Heat*, *Electricity*, *Galvanism* and *Magnetism*, *all* depend for the exhibition of their several functions upon the *same* ethereal, illimitable agent, only differing in its modes of action and forms of manifestation, and these, perhaps, mainly dependent upon the condition and properties of the bodies upon, or through which it acts, as solids, liquids and gases, of different chemical or material constitutions, and the circumstances by which it is surrounded. Hence they are mutually reproductive, each of the other. A few instances given will illustrate what we mean by this phrase, viz: Light developes Heat. For example: If equal volumes of Hydrogen and Chlorine gases are mixed in a glass jar, over a pneumatic cistern, and kept covered with *black* cloth, no action takes place between them. But if the sun's rays are thrown in through a door or window from a reflected mirror directly upon the jar, although held at the distance of fifty or sixty feet from it, the *black* cover being *removed*, the two gases almost instantaneously combine with a powerful explosive reaction, resembling the report of a pistol or musket, and Hydrochloric Acid alone is found in the jar. *Light* generates Magnetism as in Miss Summerville's experiment, in which a fine needle was

magnetized by holding it on the violet rays of the spectrum, thrown from a glass prism. Again *Heat* produces Light as in the case of iron or other metals. A *dull red* Light is given off at about the temperature of 980 degrees Farenheit—invisible except in the dark; a *bright red* light seen in the day at nearly 1160 degrees Farenheit and a full dazzling *white light*, at about 3000 degrees, Farenheit. Heat, too, generated by friction, turns a file into a magnet, and ignites parlor matches which emit light. Electricity also produces light, as in the spark lightning, the Aurora Borealis, through Edison's horse shoe Carbon, etc. It also generates magnetism. For example: When a current is sent along a wrapped copper wire, wound spirally around a small bar of soft iron, whether straight or bent like the letter U, the bar is instantly converted into a magnet, the one extremity exhibiting Boreal (North) and the other Austral (South) Magnetism, determined according to the course of the current. As soon as the current ceases to flow the iron is demagnetized.

Once more, Galvanism, acting generally by plates of Zinc and Copper in contact with diluted Sulphuric Acid, generates powerful electrical currents accompanied with Heat, Light and Magnetism. This reciprocity of action or correlation of forces has given rise to at least four new departments of Science, viz: *Electro magnetism*, in which Electricity excites Magnetism; *Magneto-electricity*, where Magnetism evolves Electricity; *Thermo-electricity*,* illustrating the production of electrical phenomena by heat; and lastly, *Electro-physiology*,** or the agency of the Electric Fluid generated by the powers of life or the functions of living bodies, exerting its controlling influence upon the nervous system and the whole animal economy.

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*This was discovered by Prof. Siebeck, of Berlin in 1822, to take place when two different metals, as German Silver (an alloy of Nickel with Copper) were laid in slight contact with Antimony;

Signal instances of peculiar vital organism, adapted to the production, at will, of strong electric discharges, after the manner of a Galvanic Battery, are found in the torpedo, and Gymnotus Electricus, or the Electric Eel of Surinam, South America. This must suffice for the eye of the student. We need only add that the foregoing laws and their reported phenemona are all regarded as demonstrable with suitable apparatus and expert manipulation. And now to our main subject. It is to Thermo-electricity, then, we are to attribute the phenomena manifested by the Magnetic Needle. As the earth revolves upon its axis from West to East, and the sun preserves a stationary position to the whole planetary train which surrounds him, consequently the sun's *track* over the earth's surface must be from East to West, and the greatest intensity of his action must be within the equatorial belt where his rays are sent down vertically, viz: for 23½ degrees on each side of the Equator. Along this advancing line of way, therefore, his calorific rays generate thermo-electric currents and polarize the particles of the oxides of iron, nickel, cobalt, ferruginous sand, and all other bodies capable of magnetic excitation, extending to a considerable distance below the earth's surface and in the neighborhood of that belt. So that a well balanced Needle, each arm from the center being of equal weight and supported at the center by a sharp pointed iron or steel wire, fixed vertically in a pedestal of wood, will, at the magnetic Equator, assume and maintain a directly horizontal posi-

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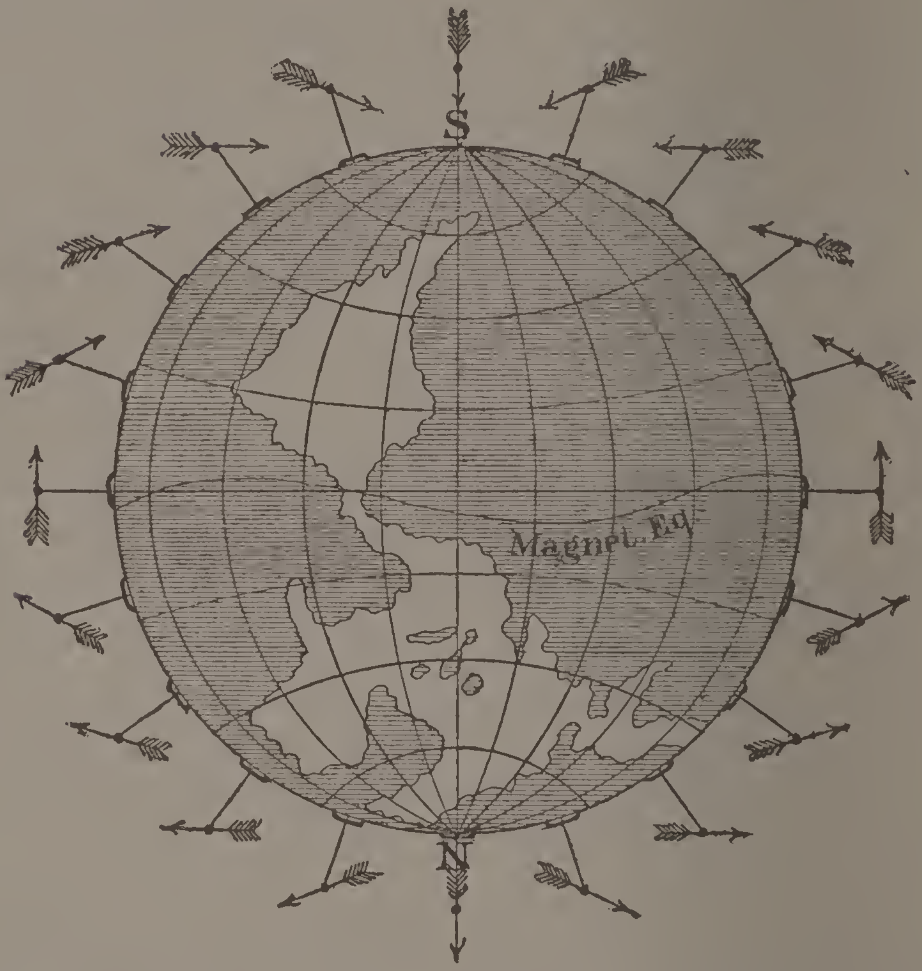
or Silver with Antimony, etc., etc., and both heated at the point of junction. The current flowing from the German Silver to the Antimony. etc. Indeed eighteen or twenty different metalic arrangements generate currents more or less intense.

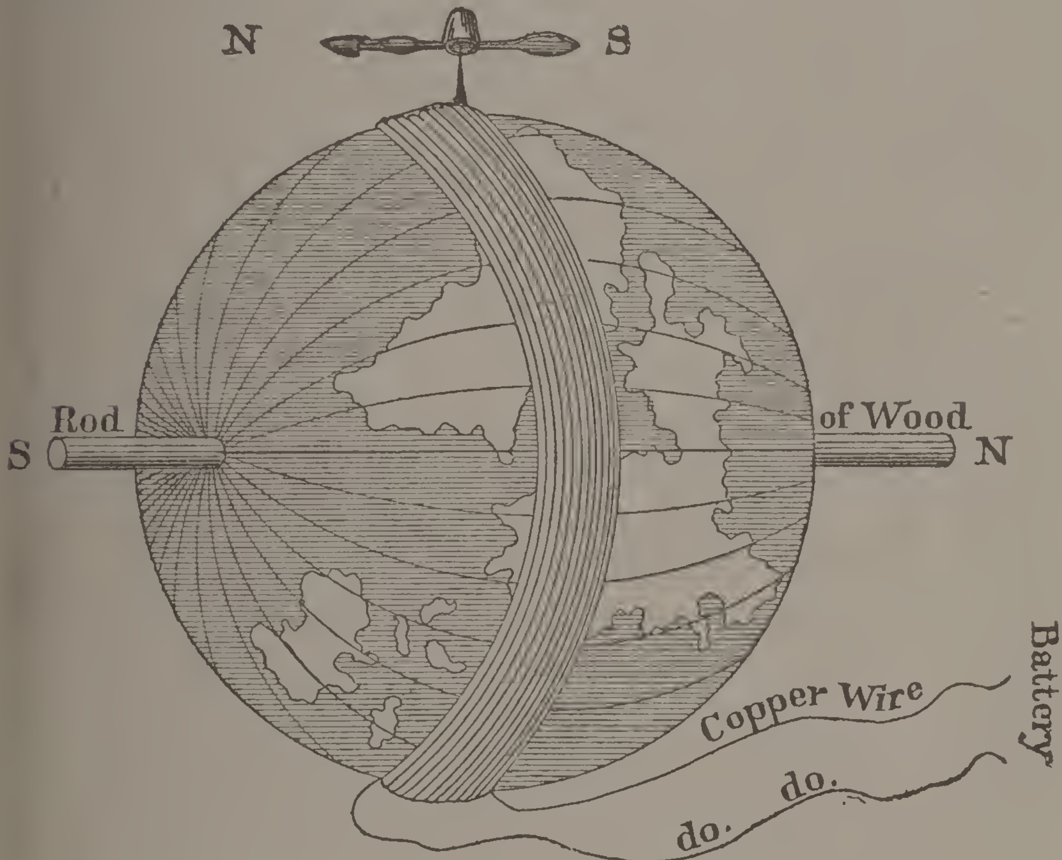
**See Dissertation on Electro-physiology republished in Medical and Surgical Journal, Atlanta, Ga., numbers December, 1877, and January, 1878, by A. Means, M. D., D. D., L. L. D.

tion, being equally attracted on both sides; so that its arrow head indicates Northern polarity and points toward the Pole in the Northern hemisphere which is *really* the South Pole of the earth.



Now it will be found if this Needle is carried on Northward its arrow-head will begin to dip earthward—the dip increasing for every degree of Latitude passed until having reached the terrestrial Pole, it will point directly downward and nearly in a line with the earth's axis: because the *South* side of the plain of the equatorial currents, now equidistant around the globe, produces its focal magnetic effect at the Pole and attracts the *North* or *arrow-head* of the Needle directly downward. If borne thence again onward toward the Equator, the dip becomes less and less for every degree, until at the Equator it becomes again

horizontal. Let it then pass on to the other Pole and the feather end, or South Pole of the Needle, will begin to dip and continue to do so until at the Pole, the Needle will again become vertical, but its arrow-head now pointing to the zenith and its feather end downward toward the earth's center.



In our Latitude the Temperate Zone, and especially in the Southern portion of that Zone, a Needle delicately poised will traverse with sufficient accuracy for the purposes of the Surveyor or Navigator. But in regions farther North the force of the dip must be counter-poised by a small movable pledget of lead, or a few turns of wire around the *South* end of the Needle to restore equilibrium at that Latitude. As the magnetic plain of the equatorial ring of currents varies, the Pole to which its axis points must manifest corresponding changes. Here we have the probable cause of the "variations" of the magnetic Needle,

Eastward and Westward of the terrestrial pole in long periods of time. In the year 1600 the declination was Eastward. At about 1660 the Needle pointed to Zero (0) that is, North and South. After that period it commenced and continued a Westerly declination until 1818, (158 years,) when the variation was found to be 24° 30′. Since then up to the present time it has been slowly returning.

I must conclude by saying the effects of the magnetic power of our earth, superinduced by electro-dynamic force, are observable in every day life. For example: A poker, tongs and many blacksmith tools, if set down with one end pointed to the earth, and especially if they happen to be standing in the magnetic meridian, are turned into magnets while in that position.

Science within the last three-fourths of a century has extorted many invaluable secrets from the arcana of Nature. But how many more wonders are yet to reward her toils other generations must report. But they are all held in reserve until the Divine Ruler of the Universe shall discover that advancing Christian civilization is ready to receive them, and they shall be evolved from his exhaustless resources through the agency of other Franklins and Morses and Fultons.

LAWS OF GEORGIA RELATING TO COUNTY SURVEYORS.

BY

J. B. ESTES, Attorney at Law,

GAINESVILLE, GA.

§1. (566.) *How elected.*—County Surveyors are elected, commissioned, qualified and removed as Clerks of the Superior Courts are, and hold their office for two years.

§2. (1319.) *When elected.*—Ordinaries, Clerks of the Superior Courts, Sheriffs, Coroners, Tax Collectors, Tax Receivers, County Surveyors, and all county officers, shall be elected on the first Wednesday in January of the years in which, under the Constitution and laws of this State, elections should be held to fill such offices, beginning on the first Wednesday in January, 1873.

§3. (1320.) *Official term of County Officers.*—The terms of the present Sheriffs, Clerks of the Superior Courts, Tax Collectors, Tax Receivers, County Treasurers, County Surveyors and Coroners shall begin on the first day of January, 1873, and expire on the first day of January, 1875. And all succeeding terms of said officers shall begin on the first day of January, and expire on the first day of January two years next thereafter.

§4. (567.) *Failure to elect.*—In case there is a failure to elect a person who is commissioned and qualified at the regular time, or a vacancy occurs, the Ordinary must appoint such Surveyors until the vacancy is filled according to law.

§5. (568.) *When appointed by the Court.*—If a County Surveyor derives his authority from appointment, he needs

no commission beyond the order of such Ordinary entered on his minutes, of which appointment the Governor of the State must be informed without delay.

§6. (569.) *Oath and Bond.*—Before entering on the duties of his office, besides the oath required of all civil officers, he must take the following:

"I . . . swear that I will, to the best of my skill and knowledge, discharge the duties of Surveyor of . . . . County, and that I will not admeasure, survey or lay out any land in my capacity as such, or knowingly permit or cause it to be done, without a warrant first obtained for that purpose, so help me God."

He shall also at the same time give bond and security in the sum of one thousand dollars.

§7. (570.) *May be removed.*—Whether appointed or elected, besides the causes of removal which apply to all officers, he may be removed by the Ordinary for want of capacity, on the same proceeding before him, and by him to be decided, that officers are removed in the Superior Courts.

§8. (571.) *One for each county.*—There must be one for each county, and he is empowered to appoint one or more assistants or deputies, for whose conduct he is responsible.

§9. (572.) *Must take an Oath.*—When such an assistant is appointed he must take the same oath the Surveyor takes, and the fact of the appointment must, at the same time, be entered on the minutes of the Ordinary.

§10. (573.) *Office, where kept.*—The County Surveyor may keep his office at his place of abode.

§11. (574.) *Duties.*—It is his duty—

1. To punctually observe and carry into effect all such

orders as he may receive from the Surveyor General or other officer who may lawfully command him.

2. To admeasure and lay off dower, to partition land, to make re-surveys, to give plats of all surveys and to administer all oaths required by law in such cases.

3. To survey county lines and district lines, or other surveys in which his county may be interested, whenever required by the Ordinary.

4. To execute all surveys required by the rule of any Court of competent jurisdiction.

5. To keep a well bound book in which shall be entered plats of all surveys made by him, with a minute of the names of the chain-bearers, when executed, by whose order and to whom plat delivered, if any; which book shall belong to his office and be turned over to his successor, and when full shall be deposited in the office of the Ordinary.

§12. (575.) *Fees.*—When surveys are made for private or corporate benefit, the fees are to be paid by the person or persons, or corporation who orders the survey; when by order of the Ordinary, out of the county funds; and when by rule of Court, unless otherwise agreed upon, they are to be taxed in the bill of costs, and shall have the effect of a judgment lien upon the land surveyed if not paid by the party bound for costs.

§13. (576.) *Survey between Counties.*—When a survey is made by agreement, or in compliance with the law between two or more counties, the County Surveyor who performs the survey is to be paid by his county, which must collect from the other counties their proportion.

§14. (577.) *Payment of Fees.*—If, after a County Surveyor has made a survey for any person, who neglects to pay him, such surveyor, upon making oath before the Ordinary of his county of the performance of such service

and its value, such Ordinary shall issue a fi. fa., in the name of the Ordinary for the use of such Snrveyor against such defaulter, who may defend himself therefor, in the same manner as persons against whom executions issue who detain county funds.

§15. (578.) *Surveys when Evidence.*—Surveys or plats of land made by the County Surveyor, under order of Court, and on notice to all the parties, of lands within his county, signed by him officially, and stating the contents, courses, distances, of any land surveyed by him, are presumptive evidence of the facts, if all the requisites of the law touching such surveys and the reports thereof are complied with.

§16. (579.) *Where there is no Surveyor.*—When there is no County Surveyor, any competent person, a citizen of the county, may perform his duties when specially required, if first sworn to do the same skillfully, faithfully and impartially, to the best of his knowledge; or in default of such person the County Surveyor of an adjoining county may officiate.

§17. (580.) *Persons acting.*—Persons performing such service are on the same footing as County Surveyors as to the special service rendered, and are personally liable as such surveyors are officially.

§18 (581.) *False survey*—When any County Surveyor or other person acting as such, has knowingly surveyed land as vacant land which is not, or so made any other false survey, he is guilty of a misdemeanor, and on indictment and conviction shall be imprisoned not longer than six months

§19. (2371.) *Duty of, in case of head rights.*—If no caveat is filed, or if filed, is not sustained, the said Ordinary shall issue a warrant directed to the County Surveyor requesting him to view the land alleged to lie vacant, and

if upon due examination of the adjoining surveys he is satisfied that the same is vacant, to make an accurate survey and plat of the same, and return the plat to the said Ordinary with his official certificate as to its accuracy, the time of survey, and his opinion that the same is vacant. Notice of the time of survey shall be given to all the owners of adjacent lands, resident within the county, by the County Surveyor at least ten days before the time appointed, and like notice of any delay or postponement of the time.

§20. (2372) *His certificate if the land is granted.*—If the County Surveyor shall be satisfied that the land is not vacant, he shall certify the fact to the Ordinary issuing the warrant, with the name of the grantee or grantees, to whom, in his opinion, the same has been granted, and return the warrant to the Ordinary. The applicant, if he sees proper, may take issue upon such return, and such issue shall be transmitted to the Superior Court, in like manner as a caveat, to be there tried. The Superior Court shall give notice in the most practicable manner to the owner or owners of the old grant or grants of the pendency of such issue before the trial of the same. If the issue is found for the applicant the survey shall proceed.

§21. (2373.) *False return by Surveyor.*—Any County Surveyor who shall knowingly or without due precaution, certify as vacant, land covered by former grant, shall be liable, with his sureties on his bond, to the owner of such land for double the value of the same, at any time before the trial of the cause.

Explanation.—The number with section mark (§) prefixed is the section of this chapter. The figures included in brackets at the beginning of each section refer to the section of the Revised Code of Georgia, where the same is found.

Decisions of Supreme Court of Georgia on foregoing sections of law.

Rule of survey taken out pending an action of Ejectment: 28 Ga., 465.

Certificate of County Surveyor as evidence: 21 Ga., 113. Requisites of warrant: 14 Ga., 349; 29 Ga., 754; 33 Ga., 296. Amendment of: 29 Ga., 753.

TEXAS LAND SYSTEM AND LAND SURVEYING.

BY

Col. WARREN DOUGLAS,

PRACTICAL SURVEYOR, CLEBURNE, JOHNSON COUNTY, TEXAS.

Texas land surveys and grants are based upon land certificates authorizing the grantee to have surveyed out of the public domain, by any legally authorized surveyor, so much land; and upon the return of the certificate, together with the field notes of the land surveyed, to the General Land Office of the State, the holder, all things being regular and correct, is entitled to a grant, or letter patent to the land described in the field notes. Legally authorized surveyors of Texas are District Surveyors and their Deputies. Originally, the State was divided by law into a very few districts, embracing large extents of territory; each District Surveyor was required to keep a map of his district and a record of all surveys made by him, or his deputies, returning the original field notes to the Commissioner of the General Land Office, to whom all were subordinated. Afterwards, as the country became populated, each county was authorized by law to erect itself into a land district, by having a transcript from the records of its original district, of all the surveys within its own limits, taken at its own expense.

Many counties have availed themselves of this privilege, and a surveyor of a land district comprising one county, is called indifferently a *district* or a *county* surveyor and may have his deputies. But in Texas, the duties of a district or county surveyor have reference to the Public Domain only; the dividing or partitioning of surveys and

the determination of boundaries being left to mutual consent of parties or to surveyors appointed by Decrees of Courts. Owing to the system of land surveying adopted by the Republic and State of Texas, or rather followed out by them, for it was practiced by Spanish and Mexican authority, and to the further consideration that at an early day, and even now, on the extreme frontier, surveying, in the wilds of Texas, was extremely dangerous, that Texas land and land certificates were regarded as of trifling value, often the fees for entering and surveying land amounting to almost the full value of the certificate, and that each surveyor, or deputy, worked in the field without actual supervision or control, little uniformity could be expected, and in fact, little is to be found. The writer has found in the same county a difference of nearly four degrees in the running of different surveyors, or, in other words, *variations* of from 8° 30′ all the way up to 12°, the true magnetic variation, in this section, being about 9° 40′ E., and errors, (usually excesses) of measurements running from 1 to 10 per cent in the length of lines. As the principal duty of the present and future surveyors will be to re-establish the boundaries of surveys made long before, and as he must follow the footsteps of the original surveyor, it becomes his business rather to ascertain *what variation* of his needle will cause his compass to follow the courses indicated by the calls in his field notes, in the particular survey upon which he is called to work, than to determine what is the true magnetic variation. For this purpose he will first *train* his compass by running first on the best marked line of the survey, or from one well established corner to another, or to some distinct and indisputably marked point in the boundary, as a fore and aft tree. Here the surveyor needs a rule for correcting errors of this kind which are usually small, or within one or two degrees. I offer the following one, not as being the best or shortest, but as

easy to remember, and in reach of the common arithmetician and easily reduced by him to practice.

RULE.

Consider the distance run the radius of a circle, and the error a part of its circumference. Calculate the circumference and divide by 360 and you have the value of a degree of said circle; divide this by, or into your error and you have it, the error, expressed in degrees or fractions of a degree. For example:

Suppose a distance run of 700 varas, error 13 varas. Then $700 \times 6\frac{2}{7} = 4400 \div 360 = 12\frac{1}{4} = 1^\circ$. But error is 13 equal to $1\frac{1}{49}$ degree $= 1\frac{1}{16}^\circ$ or $1^\circ\ 4'$ nearly.

This formula though not *absolutely* correct, is more nearly so than any practical adjustment of the compass can be, and will give satisfactory results. Having set the compass now 1°–$4'$ to the right or left as the case may be, continue to the next certain point in the same line. If you find yourself again in error you may suspect a false run or crook in the original line: note your error at this point, move into the true line and proceed as before, and so on, until the termination of the line is reached, at which note error both in course and distance from the initial point, if it be a fixed and well ascertained position. Now you will have the data to calculate the true course, from the beginning to the termination of the line and to find the true position of the intermediate marks with reference to it. If they be upon this line, or alternately to the right and left, readjust your compass by the above formula so as to run correctly the whole line and assume that to be the true course of that line, and your variation so ascertained as the one likely to follow the remaining lines of that particular survey. But if the intermediate marks or a number of them indicate a straight line on a course diverging from the line from the corner, you will suspect a mistake; either

the surveyor you are trying to follow has diverged from a line he has called for, and followed by supposition, or described a corner taken from other field notes and which he did not actually run to and establish, or some subsequent surveyor has run and marked a line in error. Consider what would most likely solve the difficulty. Adopt the one line or the other as your base and proceed as before with your next line. If in this you find yourself in error as before, note carefully the error, remembering that there is most likely parallelism in the opposite lines of a survey, even though the angles be not accurately measured.

In resurveys, follow the marks specified in your field notes and respect corners originally made, if they can be identified, regardless of course and distance. In re-establishing old corners, make the unknown correspond to and agree with the known corners or mark as actually situated on the ground. When one line is known or tracable, establish its opposite if untracable, by parallelism with it. When but one line of a survey may be traced, establish all others in harmony with it as to magnetic variation. When only one course is known or can be identified, run in harmony with surrounding surveys as to magnetic variation, especially if made by the same surveyor. But when this cannot be ascertained, run according to the true variation and observe distance strictly.

PARTITION.

In subdividing lands, first ascertain all that can be known as to actual boundaries of the survey and the gain or loss in actual area. If the parties to the partition are mutually interested in it as a whole, as in case of partition among heirs or partners, the gain or loss is to be distributed among the several parts "pro rata." But if one or a number have purchased a specific amount of land from another, then said amount is to be accurately laid out; the gain or

loss remaining with the vendor. Partition lines should maintain exact parallelism with original boundaries.

ERRORS.

A few remarks now on occasional or accidental errors in the lines of Texas Surveyors.

1st. A *false run* or *deflection* of course. This may happen in two ways—*first*, in running lines by natural objects, the eye being removed for an instant from the object, another similar in appearance, but different in fact is mistaken for the true object and the remainder of the course actually run, be in error by the distance of the false object from the true line. *Secondly*, The fastening of the vernier may become loosened and the "*set*" of the compass disarranged and escape the notice of the surveyor. This, of course, makes bad work.

2d. Marking is sometimes done in error, by the surveyor departing slightly from his course to avoid obstructions, followed by the marker. This is an irregularity of frequent occurrence in Texas surveying; it is of easy detection and comparatively harmless in its consequences.

3d. Clerical errors are of frequent occurrence, the most common being the use of a wrong initial letter in indicating the course of a line, as S. for N., E. for W. and *vice versa*. These mistakes are usually apparent and flagrant and when they apply to the course or bearings given in field notes from corners of a survey to witness trees or monuments, they are not palpable and cannot be disregarded or set aside except by the strongest evidence in other marks made and described in the field notes. Unfortunately, this kind of mistake is but too frequent. Sometimes, the figures expressing degrees are transmuted with those expressing distance, as N. 27, W. 27 varas becomes N. 27, W. 47 varas. Therefore too much care cannot be exercised in taking field notes.

MEASUREMENTS.—VARAS, LABORS AND LEAGUES.

These are terms of Spanish land measurement, lineal and square, and were used in giving and surveying land grants in Texas under Spanish and Mexican authority. Upon the accession of Anglo American authority, the English and American square measure of acres and sections was introduced (perhaps as being more comprehensible to the American mind) but owing to the great inconvenience involved in a change of the unit of lineal measure, the Texas Land Office still retains, and no doubt will ever retain, the *Vara* as the unit of length. Hence, we have in Texas, land grants expressed in square varas, labors (pronounced labóres) and leagues, their multiples and fractions, and others expressed in acres and sections with their multiples and fractions, but at the same time our Texas land system knows no unit of lineal measure save the *vara*. All surveys returned to the General Land Office must have their dimensions expressed in *varas*; as, for instance, a square section of 640 acres will be described as being in the length of each boundary 1900 *varas* instead of one mile, or so many rods or yards:

TABLE OF SPANISH LAND MEASURE.

1 Vara	$33\frac{1}{3}$ inches.
1 Acre . . . . 5646 square varas—4840 square yards.	
1 Labor . . . . . . 1,000.000 square varas—177 acres.	
⅓ League . . . . 8,333,333.00 square varas—1476 acres.	
1 League . . . . . 25,000,000 square varas—4425 acres.	
1 League and Labor, 26,000,000 square varas—4605 acres.	

To find the number of acres in a given number of square varas, divide by 5646—reject fractions.

It will be seen from the above table that the *vara* is equal to thirty-three and one-third inches (English) or, 3 varas=100 inches. Hence, to reduce varas to inches,

annex two ciphers and divide the result by 3. To reduce varas directly to yards annex two cyphers and divide by 108.

The Labor, square measure, is equal to 1,000,000 square varas, or, a square survey of 1,000 varas square. It is equivalent to 177 acres.

The League, square measure, is equal to 25 labors, or a square survey of 5 000 varas to the side, or to 4425.

The equivalents of varas, etc., in miles and acres are only proximately used and passed in Land offices and general practice as counts.

The Official Scale in General Land Office for platting is 4,000 varas to the inch. Double scale is allowed in plats returned with field notes.

Chains in Texas are of 10 or 20 varas in length, and should have five links to the vara. Fractions of varas are expressed in *tenths*, not *links*.

The primary principles of surveying, platting and getting area are the same in Texas as elsewhere, with the applications and requirements here set forth.

Advice to Young Surveyors.

It may not be considered improper in the author to venture a word or two of useful advice before parting with the student.

In selecting assistants in your field work never call to your aid *John Barleycorn*, sometimes called *whisky*, *brandy*, and *rum*. *John* is thought by many to be a pleasant and important companion on works of this kind, but by his might the strong man has fallen and the promising young man has found an early grave. If you take him in your employ your bearings will very likely be wrong, your field notes incorrect, the platting a disgrace and your reputation ruined. He can never do you the least service in any department of the work, but is sure to destroy your usefulness as a Surveyor. Therefore let one who wishes you well beg you to shun all such assistants.

USEFUL TABLES.

LENGTH OF EACH SIDE OF A SQUARE CONTAINING

1 Acre in feet, fractions rejected	208
2 Acres " " "	295
3 Acres " " "	361
4 Acres " " "	417
5 Acres " " "	466
6 Acres " " "	511
7 Acres " " "	552
8 Acres " " "	590
9 Acres " " "	626
10 Acres " " "	660

LAND MEASURE.

In England and the United States the acre consists of 160 square rods, or 4,840 square yards, or 43,560 square feet. In Scotland the acre is 6,840 square yards.

MEASURE OF DISTANCES.

A mile is 5280 feet; 1760 yards; 320 rods; or 80 chains.

A rod is	$16\frac{1}{2}$ feet.
A fathom is	6 feet.
A league is	3 miles.
A cubit is	2 feet.
A great cubit is	11 feet.
A hand (horse measure) is	4 inches.
A palm is	3 inches.
A span is	$10\frac{7}{8}$ inches.
A pace is	3 feet.

QUANITY OF SEED USUALLY SOWN TO AN ACRE.

Herd's grass, or Timothy	$\frac{1}{4}$ to $\frac{1}{2}$ bus.	Carrot	$2\frac{1}{2}$ to 3 lbs.
Red Top	$\frac{1}{2}$ to 1 bus.	Beet	4 to 6 lbs.
Red Clover	6 to 10 lbs.	Parsnip	3 to 5 lbs.
White Clover	5 to 8 lbs.	Onion	4 to 6 lbs.
Lucerne	10 lbs.	Ruta Baga	1 lb.
Orch. Grass	1 to $1\frac{1}{2}$ bus.	Turnip	1 to $1\frac{1}{2}$ lbs.
Blue Grass	$\frac{1}{2}$ to 1 bus.	Beans	$1\frac{1}{2}$ to 2 bus.
Rye Grass	1 to $1\frac{1}{2}$ bus.	Peas	$1\frac{1}{2}$ to 2 bus.
Wheat	$1\frac{1}{2}$ to 2 bus.	Oats	$2\frac{1}{2}$ to 3 bus.
Barley	$1\frac{1}{2}$ to 2 bus.	Rye	$1\frac{1}{4}$ to $1\frac{1}{2}$ bus.
Buckwheat	1 to $1\frac{1}{2}$ bus.	Millet	$\frac{1}{2}$ to $\frac{3}{4}$ bus.

QUANTITY OF CORN REQUIRED TO PLANT AN ACRE, FIVE GRAINS IN THE HILL.

3 feet by 2	18 qts	3 feet by 3	12 qts.
3½ feet by 2	10 qts.	3¾ feet by 3	8 qts.
3 feet by 4	7 qts.	4 feet by 4	6 qts.

THE NUMBER OF PLANTS PER ACRE, AT GIVEN DISTANCE.

1 foot	43,560	6 feet	1,210
1½ feet	19,360	9 feet	537
2 feet	10,890	12 feet	302
2½ feet	6 969	15 feet	194
3 feet	4,840	18 feet	134
4 feet	2,722	20 feet	109
5 feet	1,742	25 feet	69

One acre of Tobacco set 4 feet by 2½ distant, will contain 6,050 plants. Most growers prefer 3½ feet by 2, which gives 6,223 plants to one acre.

RECOMMENDATIONS.

UIVERSITY OF GEORGIA.
ATHENS, Nov. 15th, 1880.

I have examined the manuscript of "Caldwell's Practical Surveying," and believe it just such a work as will meet the wants of the large class of Surveyors and students who desire to learn this art practically and in a short time. I have long wished for such a book to meet the wants of our average County Surveyors. By his request, I have furnished several chapters on *practical* methods which are the result of my long experience as a Surveyor. The chapter on "*Annual Variation of the Needle*," is so important to the average County Surveyor, that I am glad to have the opportunity of presenting the *practical method* of determining it for any particular locality. And hope it will be the means of preventing lawsuits about land lines in future.

I hope to see the book meet with a heavy sale.

WILLIAMS RUTHERFORD, A. M.,
Prof. Mathematics, University of Ga.

GAINESVILLE, GA., Nov. 17th, 1880.

I have examined the manuscript of Caldwell's Practical Surveying, and find it to be a work eminently fitted to fill the place it is designed to occupy. There has long been a need of just such a work—it is clear, concise and *practical.* It will be an excellent book to put into the hands of a boy that has a fair knowledge of arithmetic, and even old surveyors will find in it much useful information condensed into a small space.

C. B. LAHATTE,
President of the Methodist College, Gainesville, Ga.

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